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POLLUTION AFFECTING SHELLFISH HARVESTING IN MOBILE BAY, ALABAMA

T. P. Gallagher, et al

Federal Water Pollution Control
Administration
Athens, Georgia

August 1969

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POLLUTION AFFECTING SHELLFISH HARVESTING IN MOBILE BAY, ALABAMA

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Athens, Georgia

August 1969

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I. INTRODUCTION

This report summarizes and relates pertinent shellfishing statistics and water quality and waste source information from 1949 through 1969. The cooperation of the U. S. Bureau of Commercial Fisheries, U. S. Public Health Service, Alabama Water Improvement Commission and the Alabama Conservation Department as well as the municipalities and industries in the area, particularly the employees of the city of Mobile, is gratefully acknowledged.

II. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Shellfishing areas in Mobile Bay have been closed by the State of Alabama during portions of eight of the past sixteen years because total coliform densities over the beds exceeded the 70/100 ml total coliform standard for shellfish harvesting.

2. A comparison of monthly production figures for shellfish harvesting in Mobile Bay from 1954 to 1967 during open and closed periods shows substantial harvesting losses and, consequently, substantial economic losses during the closure periods. The respective average production losses during the months when closures due to pollution have been in effect are 35,000 pounds in February, 51,000 pounds in March and 28,000 pounds in April. The net production loss is approximately 109,000 pounds per year. The corresponding economic losses, based on an as-landed value of 0.52¢ per pound averaged for January 1969 in Mobile and Baldwin Counties, are $18,200 in February, $26,500 in March and $14,600 in April. A recent study of the Florida shellfish industry indicated that the final retail value of shellfish products is roughly four times the as-landed value. Therefore, the annual economic loss to the region ranges from $56,700 (as-landed value of oysters) to $227,000 (estimated retail value).

3. The most significant source of coliform pollution to Mobile Bay is the Mobile River. The coliform pollution entering Mobile Bay from the Mobile River is transported down the western shore of the Bay to the major shellfishing areas during flood runoff periods. The great majority of both total and fecal coliforms entering the Bay from the Mobile River originate in the Mobile metropolitan area.

ERRATA

II. CONCLUSIONS AND RECOMMENDATIONS

Pages 2 and 3

6. The most significant contributor of bacterial pollution from point sources in the Mobile metropolitan area is the untreated section of Mobile. The median total and fecal coliform population equivalents from this source are 46,500 and 13,700 BPE respectively. This waste accounted for 39.4 percent of the total coliform and 47.3 percent of fecal coliform contributed from all sources. The second major source is the International Paper Company which discharges 55,900 or 47.4 percent of the total coliform and 9,780 BPE or 33.8 percent of the fecal coliform.

7. The four industrial effluents sampled--International Paper Company, Scott Paper Company, National Gypsum Company and Stone Container Corporation, contribute 66,060 BPE or 56.1 percent of the total coliform and 13,000 BPE or 44.9 percent of the fecal coliform discharged in the Mobile metropolitan area. The eight domestic waste sources sampled discharged 5,330 BPE or 4.5 percent of the total coliform and 2,250 BPE or 7.8 percent of the fecal coliform.

8. During the short periods of time when they occur, storm water overflows are significant sources of coliform pollution. During the relatively light rainfalls when storm water sampling was conducted, coliform contributions in storm water runoff amounted to three to 14 percent of the 117,900 BPE total coliform and 28,950 BPE fecal coliform pollution from point sources. More intense rainfalls would likely produce a greater percentage.

4. The median total coliform densities in the Mobile River at the mouth during flood runoff periods ranged from 150,000 to 11,000 MPN/100 ml. Seventy seven to 94 percent of this total resulted from discharges in the Mobile metropolitan area. The corresponding range of median fecal coliform densities in the river at the mouth was 930 to 300 MPN/100 ml. Sixty to 79 percent of this total resulted from discharges in the Mobile metropolitan area. During a low flow period examined, the respective median total and fecal coliform concentrations at the mouth of the Mobile River were 9,300 and 2,300 MPN/100 ml. The contribution of the Mobile metropolitan area amounted to 96 to 97 percent of the total coliform densities and 99 percent of the coliform densities flowing into Mobile Bay from the River.

5. Ninety-seven percent of the Mobile area's municipal waste is now receiving secondary treatment and chlorination. However, the coliform density increases in the Mobile River indicate that excessive quantities of total and fecal coliforms are being discharged by Mobile's Threemile Creek and Eslava Creek sewage treatment plants, Chickasaw Lagoon, Stone Container Corporation, National Gypsum Corporation, Scott Paper, International Paper and the untreated section of Mobile.

6. The most significant contributor of bacterial pollution from point sources in the Mobile metropolitan area is the untreated section of Mobile. The median total and fecal coliform population equivalents from this source are 46,500 and 13,700 BPE respectively. This waste accounted for 50.3 percent of the total coliform and 58.3 percent of fecal coliform contributed from all sources. The

second major source is the International Paper Company which discharges 36,040 or 38.9 percent of the total coliform and 6,300 BPE or 26.9 percent of the fecal coliform.

7. The four industrial effluents sampled--International Paper Company, Scott Paper Company, National Gypsum Company and Stone Container Corporation, contribute 43,000 BPE or 46 percent of the total coliform and 8,400 BPE or 33.6 percent of the fecal coliform discharged in the Mobile metropolitan area. The eight domestic waste sources sampled discharged 3,440 BPE or 3.7 percent of the total coliform and 1,500 BPE or 6.1 percent of the fecal coliform.

8. During the short periods of time when they occur, storm water overflows are significant sources of coliform pollution. During the relatively light rainfalls when storm water sampling was conducted, coliform contributions in storm water runoff amounted to 4 to 18 percent of the 92,500 BPE total coliform and 23,500 BPE fecal coliform pollution from point sources. More intense rainfalls would likely produce a greater percentage.

9. There is a direct, though imprecise, relationship between river flow in the Mobile River above Mobile and both total and fecal coliform densities. As river discharges increase, total and fecal coliform densities will also increase irrespective of point sources of waste.

10. The concentrations of total and fecal coliform in the Mobile River above Mobile during high flood runoffs are such that even if the bacteriological contribution from all sources at Mobile were removed and all other conditions remained constant, it is doubtful

whether the 70/100 ml total coliform criterion for shellfish harvesting could be met anywhere in Mobile Bay except Bon Secour Bay.

11. Sewage, storm water overflows, and industrial wastes discharged to the Mobile River from the Mobile metropolitan area, and excessive concentrations of total and fecal coliform in the Mobile River above Mobile during high flood runoff, result in pollution of Mobile Bay by bacteria. Because of this pollution, the State of Alabama under the laws of the State and the rules and regulations of the Alabama State Board of Health governing the production, shucking and handling of oysters, has closed more than 4,270 acres of oyster beds to the direct harvesting of shellfish. These closures have caused substantial economic injury resulting from the inability to market shellfish or shellfish products in interstate commerce. The estimated economic loss to the region ranges from $56,700 to $227,000 annually. Accordingly, the pollution of these navigable waters is subject to abatement under the provisions of section 10 of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.).

Recommendations

It is recommended that a pollution abatement program requiring the following measures be instituted:

1. Secondary treatment and effective year-round disinfection be provided for all municipal wastes. Operation of all waste treatment facilities to accomplish the highest possible removal efficiencies at all times. This recommendation is to include the following specific measures for the sources of municipal wastes listed below:

A. Threemile Creek sewage treatment plant (Mobile)--Effective disinfection of waste effluent at all times.

B. Eslava Creek sewage treatment plant (Mobile)--Expansion of plant capacity and effective disinfection of waste effluent at all times.

C. Untreated sewage discharge from downtown Mobile--Construction of interceptor sewers for diversion to McDuffie Island sewage treatment plant. This recommendation is already being implemented.

D. Storm water overflows (Mobile, Prichard, Chickasaw)--Regular maintenance program of debris clearance from drains.

E. Chickasaw waste lagoon--Effective disinfection of waste effluent at all times.

F. Bayou La Batre Daphne, Satsuma, Alabama--Construction of collection system and sewage treatment facilities to replace septic tanks serving individual homes.

2. All industries provide secondary treatment for both process and domestic wastes and effective disinfection where appropriate for both process and domestic wastes. Specifically, the following program is to be carried out by the industries as follows:

Industrial sources	Program
1. International Paper Co. 2. Scott Paper Co. 3. National Gypsum Co. 4. Stone Container Corp. 5. Alabama State Docks	A) Separation of process and domestic wastes. B) Secondary treatment at not less than 85% removal efficiencies and effective disinfection at all times for domestic wastes or connection to the municipal sewer system. C) Secondary treatment at not less than 85% removal efficiencies for process wastes and effective disinfection at all times.

3. The seafood processing plants in Bayou La Batre and other locations in and around Mobile Bay without adequate treatment:

a. Provide screening and separate disposal of gross solids such as hulls and heads resulting from the processing of shrimps, crabs and other seafood products.

b. Provide secondary treatment of wash water resulting from machine peeling, processing and packing of peeled shrimp and the packing of whole, unpeeled shrimp. Such treatment could be provided as part of the municipal waste collection and treatment system.

4. All recommended abatement measures be in operation no later than February 15, 1973, as detailed in the Alabama water quality standards, approved by the Secretary of the Interior on February 15, 1968.

5. In determining acceptability of areas in Mobile Bay for shellfish harvesting, a fecal coliform criterion be employed in conjunction with Salmonella determinations to more effectively

evaluate the probability of pathogen presence. A coordinated effort by the U. S. Public Health Service and the Federal Water Pollution Control Administration in cooperation with the States should be undertaken immediately to develop an acceptable numerical criterion for fecal coliform, for promulgation by health authorities, with respect to approval of areas for shellfish harvesting. A technical committee be established by the conferees to assist in and coordinate the development of an acceptable numerical criterion for fecal coliform. This committee should report to the conferees no later than one year from the date of the first session of conference.

III. BASIN DESCRIPTION

The Mobile River is formed by the junction of the Alabama and Tombigbee Rivers, approximately forty miles north of Mobile, Alabama. The river flows in a southerly direction for some forty-five river miles before entering Mobile Bay. Mobile Bay is a relatively large shallow bay with an overall area of approximately 419 square miles, an average depth of 9.8 feet, and a maximum depth of 60 feet (Figure 1).

The upper three-quarters of the Mobile River Delta is a chain of rivers, bays, bayous, and extensive swamp with a thick growth of trees. The lower one-quarter is treeless, grass-covered wetland marshes and shallow bays. The delta, unlike a typical delta, is hemmed on both sides by high land.

The Mobile River-Mobile Bay drainage basin comprises approximately 2,060 square miles of Mobile and Baldwin Counties. Although the drainage area defined by these limits is relatively small, waters flowing into this basin drain approximately 64 per cent of Alabama as well as portions of Georgia, Mississippi and Tennessee, giving a total of 44,170 square miles draining into Mobile Bay.

The average annual precipitation is 57.5 inches, which is the highest of any basin in Alabama.

Due to the large drainage area and unregulated flood flows on the Alabama and Tombigbee River, the flow into Mobile Bay through the Mobile River system varies widely, ranging from 10,000 cfs during the dry, fall months to more than 532,000 cfs during the spring floods. Construction of reservoirs on the Alabama River should have a

considerable effect on the low flow variations. Low flow on the Tombigbee River is somewhat regulated by the Jackson Lock and Dam located near Coffeeville, Alabama.

Flow in the Mobile River is influenced by natural diversion to the Tensaw River below Mt. Vernon. It is estimated that approximately 60 per cent of the flow in the Mobile River is diverted to the Tensaw during periods of low to moderate flows and 50% diverted during high flows.

All waters of Mobile Bay and the Mobile River, as well as all or portions of their tributaries, are influenced by tidal fluctuations. Mobile Bay has one tide daily, with each tidal cycle taking approximately 25 hours. Tidal fluctuations vary from less than one foot during neap tides to two and one-half feet during spring tides.

Major tributaries of the Mobile River include Threemile Creek, Chickasaw Creek and Bayou Sara. Major tributaries entering Mobile Bay, other than the Mobile River, include the Tensaw River, Spanish River, Apalachee River, Blakely River, Dog River, Fowl River and Fish River. The Spanish, Apalachee and Blakely Rivers are straits originating in the Tensaw River.

The principal cities within the Mobile Basin are Mobile, Prichard, and Chickasaw. At the present time, approximately 320,000 people reside in the immediate Mobile metropolitan area. Projections indicate that population will increase to 390,000 by 1975. The upper portion of the Bay and the Mobile River are presently heavily industrialized. However, there are still large tracts of undeveloped land, and expansion of present industries and location of new industries are anticipated. A shipping channel has been approved to connect the Deer River with the main channel in anticipation of an industrial park soon to be constructed on the Deer River.

IV. SHELLFISH MANAGEMENT

A. Procedures

Management of the shellfish industry in Alabama is jointly administered by the Alabama Department of Conservation and the Alabama Department of Public Health. The conservation agency is responsible for protection, propagation, and conservation of shellfish and other seafood resources. The health agency is responsible for carrying out sanitary controls over shellfish growing, harvesting, and handling in the interest of public health. (The term shellfish refers to oysters, clams, and mussels.) (1)(2)

In carrying out its oyster sanitation control program, Alabama participates in the voluntary National Shellfish Sanitation Program (NSSP), administered by the U. S. Public Health Service.(1) Under the NSSP, direct sanitary controls over shellfish production are applied by the individual states. In general, under these controls, shellfish harvesting areas are designated as approved when the following criteria are satisfied: a) the area is not so contaminated with fecal material that consumption of the shellfish might be hazardous; b) the area is not so contaminated with radionuclides or industrial wastes that consumption of the shellfish might be hazardous (this provision applies to the possible presence of toxins); and c) the total coliform median most probable number (MPN) of the water does not exceed 70 per 100 milliliters (ml) and not more than 10% of the samples ordinarily exceed 230 per 100 ml...in those portions of the area subject to the most unfavorable hydrographic and pollution conditions. The U. S. Public Health Service manual states that these limits need

not be applied if it can be shown by detailed study that the coliforms are not of direct fecal origin and do not indicate a public health hazard. The Alabama regulations, which constitute the legal standard, do not specifically include this latter provision. (3)

In Alabama, oysters are the only shellfish species in commercial production. The State health agency determines and classifies oyster growing areas. Three classifications are used in delineating sanitary water quality of Mobile Bay for oyster harvesting purposes. Growing areas are classified in the State oyster regulations as "Approved Oyster Growing Areas", "Grossly Polluted Closed Areas", and "Moderately Polluted Restricted Areas".(3) Growing area maps issued by the health agency identify Permanently Closed and Temporarily Open (or Closed) areas. Areas not marked closed are considered open. The areas and sizes are described in Table I. Alabama conducts sanitary surveillance on the bacteriological water quality of open, temporarily closed, and permanently closed portions of Mobile Bay on a year-round basis. These areas are shown in Figure 2.

When sanitary criteria are not met, a closure order is immediately issued by the State Health Officer, with copies of the closure sent to interested State, local, and Federal health agencies, the State conservation agency, various law enforcement officials, and to all oyster plants. The Division of Seafoods of the Department of Conservation is also notified of the required closure by telephone. A typical closure order is contained in Appendix C.

Enforcement of the closure is applied at once by the Seafoods Division, located at Dauphin Island. That agency maintains patrol

FIGURE 2

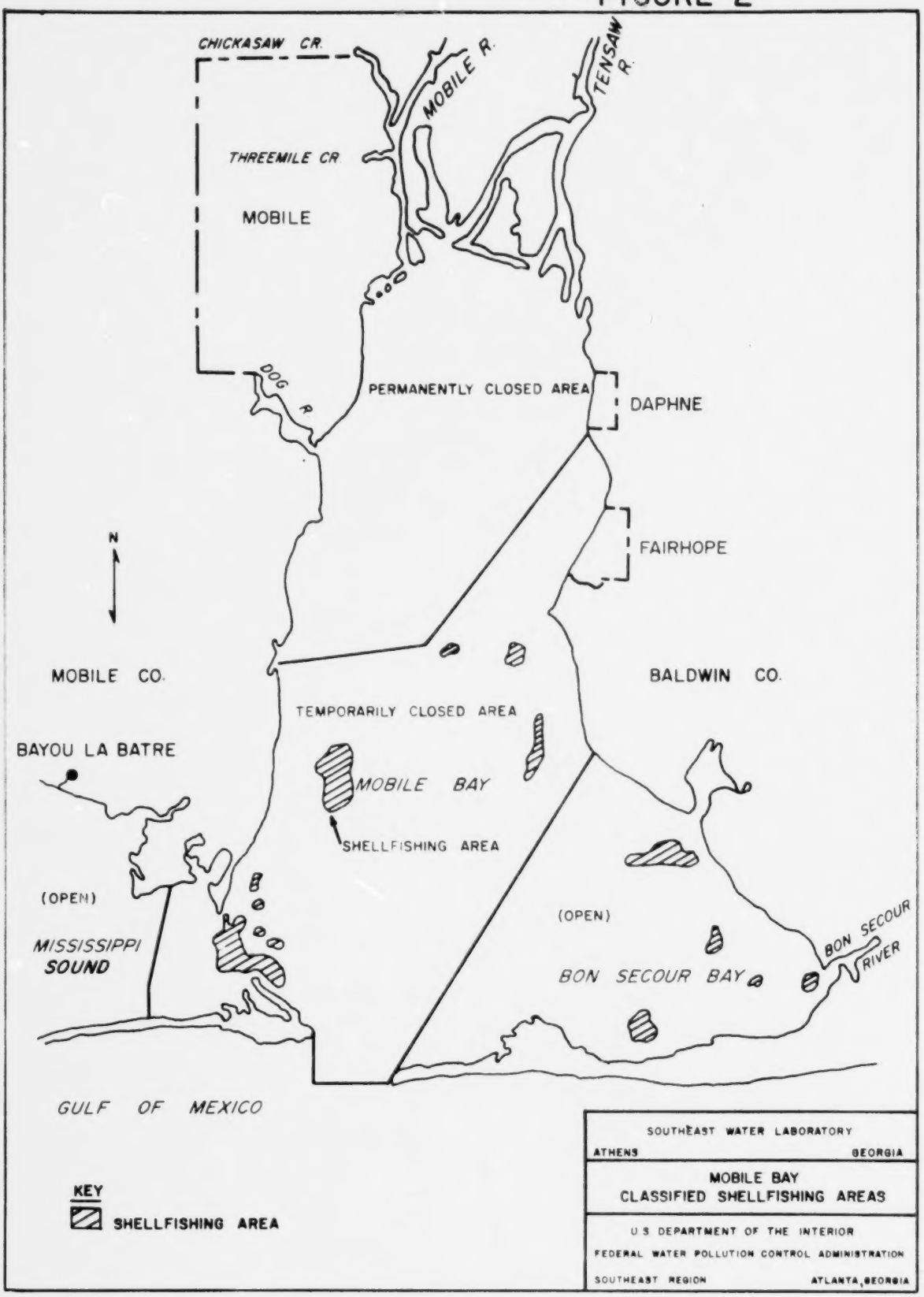

CHICKASAW CR.
MOBILE R.
TENSAW R.
THREEMILE CR.
MOBILE
DOG R.
PERMANENTLY CLOSED AREA
DAPHNE
FAIRHOPE
N
MOBILE CO.
BALDWIN CO.
TEMPORARILY CLOSED AREA
BAYOU LA BATRE
MOBILE BAY
SHELLFISHING AREA
(OPEN)
MISSISSIPPI SOUND
(OPEN)
BON SECOUR BAY
BON SECOUR RIVER
GULF OF MEXICO
KEY
SHELLFISHING AREA
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
MOBILE BAY
CLASSIFIED SHELLFISHING AREAS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

TABLE I

OYSTER GROWING AREA CLASSIFICATION
IN MOBILE BAY

Classification	Square Miles	% of Bay Area
Permanently Closed	119	28.4
Temporarily Closed (or Open)	195	46.5
Approved*	105	25.1
	419	

* Bon Secour Bay = 105 square miles

Mississippi Sound = 124 square miles (not included in above table)

operations over various phases of seafood management enforcement including the oyster closure order to prohibit oyster harvesting from permanently or temporarily closed areas. During the period when the temporary closure is in effect, State health authorities continue monitoring the waters. When the State determines that the waters have returned to a satisfactory level of sanitary quality, the temporarily closed area is opened. An opening order is issued by the State Health Officer and sent to essentially the same persons receiving copies of the closure order. A sample copy of an opening order is shown in Appendix D.

Mobile County contains the majority of oyster-producing reefs in Alabama. Most of the oyster harvesters reside in Mobile County with the major portion of oysters harvested in Alabama taken from Mobile County waters. The most productive public oyster reefs in Alabama are in the Cedar Point and adjacent areas located in the southwest portion of Mobile Bay. The important Cedar Point reef and other adjacent reefs are located within the Temporarily Closed area. When the reefs are closed, oyster harvesting is prohibited. Application of the Temporarily Closed Area order has greater impact upon Mobile County than on Baldwin County (see Appendix C).

Other productive reefs are also located in Mississippi Sound and Portersville Bay. These reefs are located outside of the Temporarily Closed Area and are not generally affected by area closures. Most of Alabama's public oyster producing areas are located in the Temporarily Closed area.

Bon Secour Bay is also an important area of oyster production in Mobile Bay. A substantial amount of shellfish harvesting in Bon

Secour Bay comes from privately leased grounds. The Bon Secour area is generally outside the limits of the temporarily closed area and thus is not affected by periodic closures.

The permanently closed waters of Mobile Bay are located in the northern portion of the Bay. The waters of the area do not meet state standards for oyster harvesting areas at any time. Degradation of water quality for oyster production is due to pollution influences from sources in and above Mobile. Oysters in the area are sparse, with few, if any, commercial reefs in existence. Information on potential productivity of the waters is lacking, e.g. suitability of bottoms or aquatic conditions to support growth. (The Division of Seafoods is currently carrying out an inventory of locations and estimated production of oyster reefs in Mobile Bay.) Commercial dredging of old shellreefs is conducted in that portion of the Bay. Dredged shell is used for road building material, feed supplements and other purposes.

B. Oyster Production in Mobile Bay

Information on Alabama oyster harvesting by county, month, volume and value was obtained from the Bureau of Commercial Fisheries, U. S. Department of the Interior.(4) Table II shows that during calendar years 1957 through 1967, Alabama produced 10,647,000 pounds of oysters valued at $3,813,000. Of this harvest, 8,817,000 pounds was produced in Mobile County at a value of $3,096,000. (The proceeding figures have been rounded off to the nearest thousand). Thus, during the period, Mobile County produced approximately 83%, on the

TABLE II

ALABAMA OYSTER LANDINGS AND VALUE BY COUNTY (5)
(In Thousands of Pounds and Thousands of Dollars)

Calendar Year	County				Totals		
	Baldwin		Mobile				
	#	$	#	$	#	$	$/#
1967	268	136	1,818	871	2,086	1,007	0.48
1966	236	101	1,068	508	1,304	609	0.47
1965	188	77	305	128	493	205	0.42
1964	228	88	777	234	1,005	322	0.32
1963	109	44	886	307	995	351	0.35
1962	167	59	277	105	444	164	0.37
1961	147	63	355	97	502	160	0.32
1960	136	46	1,034	271	1,170	317	0.27
1959	112	36	785	242	897	278	0.31
1958	81	25	378	87	459	112	0.24
1957	158	42	1,134	246	1,292	288	0.22
	1,830	717	8,817	3,096	10,647	3,813	

average, of Alabama's oyster harvest, yielding 81% of the value. Mobile County's contribution during this period ranged from 62% to 88%.

Information on the volume of Alabama oysters in interstate traffic is not readily available. However, 39 state certified dealers are shown in the January 1, 1968, issue of the Interstate Shellfish Shippers List. The figure suggests a substantial amount of dependence by the Alabama oyster economy on interstate trade.

Information on quantity and value of oysters as landed was reported continuously from 1957 through 1967. From 1950 through 1956, complete information on both volumes and values was not reported.(4) Alabama oyster harvest landings by calendar years from 1954-55 to 1966-67 are shown in Table III by oyster season.(4)(5) Data on Alabama oyster harvest and as landed values from the Bureau of Commercial Fisheries are presented on a calendar-year basis.

The Alabama oyster industry is oriented toward harvesting in terms of seasons rather than calendar years; thus, the data were rearranged to reflect production on a seasonal basis (Table III). Although the Director of Conservation is authorized to designate a seasonal closure for conservation purposes,(6) for the last several years no seasonal closure was applied and oyster harvesting was permitted on a year-round basis. Therefore, for the purpose of this report, the season of July 1 to June 30 of the following year was selected to present the data. June, July, and August are low-harvest months in Alabama, and it is recognized that the season

TABLE III

ALABAMA OYSTER LANDINGS BY COUNTY
(In Thousands of Pounds)

Oyster Season	County		Totals
	Baldwin	Mobile	
1966-67	287	2,010	2,297
1965-66	224	527	751
1964-65	223	219	442
1963-64	172	1,167	1,339
1962-63	69	562	631
1961-62	246	155	401
1960-61	103	696	799
1959-60	135	1,090	1,225
1958-59	87	467	554
1957-58	119	454	573
1956-57	135	1,133	1,268
1955-56	120	715	835
1954-55	138	1,622	1,760
	2,058	10,817	12,875

designation could have just as well start or end during any of these months.

Oyster harvesting is a highly variable phenomenon. Decreased harvest can be caused by closing productive areas because of pollution. It can also be caused by natural factors such as oyster predators, epizootics, low salinity, siltation and other environmental effects. In addition, changes in legal sizes of harvestable oysters can affect production by either increasing or decreasing the potential harvestable legal crop. Harvesting can also be affected by year-round harvesting vis-a-vis seasonal closures for conservation purposes; harvesting of steam oysters by use of power dredges increases the oyster catch if landed in Alabama.* Shifts in oyster fishing pressures caused by harvesters electing to fish for shrimp instead of oysters because of better shrimp prices and/or yield will affect oyster harvests. Thus many variables may be working independently or simultaneously to accelerate, neutralize or mask given effects of any one factor upon oyster harvesting.

From the 1954-55 season to the 1967-68 season, Mobile Bay was closed on six occasions due to pollution.(7) There were eight seasons when no pollution closure was applied. Close analysis is required if any relationship is to be developed between closures and harvest decreases. For example, during the 1961-62 season Mobile Bay was closed. Harvest for the season was 401,000 pounds. The following season (1962-63) the Bay was not closed, and the harvest was up to 631,000 pounds. However, the next season (1963-64) where a closure was necessary, the harvest was up again to 1,339,000 pounds.

*Oysters caught in one state and landed in another are credited to the landing state.

Oyster harvesting in Alabama during calendar year 1967 was 2,086,000 pounds.(8) This is the second highest reported oyster harvest year for Alabama since 1880, when statistics on oyster landings started to be collected.(4) The record year for Alabama was 1951, when 2,191,400 pounds were landed.

During the 17-year period from 1952 through January, 1968, the temporarily open area in Mobile Bay has been closed eight times because water quality over the shellfish beds did not meet State or natural shellfish sanitation program standards. A listing of the closure periods is given in Table IV. The list indicates closure dates but no reopening dates for 1952, 1953, 1961 and 1964. In 1962, two opening dates are given, and in 1965 two closing dates and one reopening date are given. Where closure periods are given without reopening dates the closure is assumed to have been in effect during the remainder of the oyster season.

C. Effects of Pollution Closures on Oyster Production

Information contained in Tables II and III, and as-landed values from the 1954-55 season through the 1966-67 season (including July 1967 through February 1968) were broken down on a monthly basis. Table V summarizes seasonal harvests and Table VI illustrates monthly distribution. Where closures were initiated or terminated in a given month, the oyster landing values during the open and closed periods of the month were proportioned to the periods when the beds were open and closed. This is based on the assumption of generally equal daily production. The earliest closure date is December 31, 1961. Two closures were in January, one in February, two in March, one in April, and one in May.

Figure 3
MOBILE BAY
AVERAGE MONTHLY OYSTER HARVESTING
1954-1968
(Production Loss Due to Pollution)

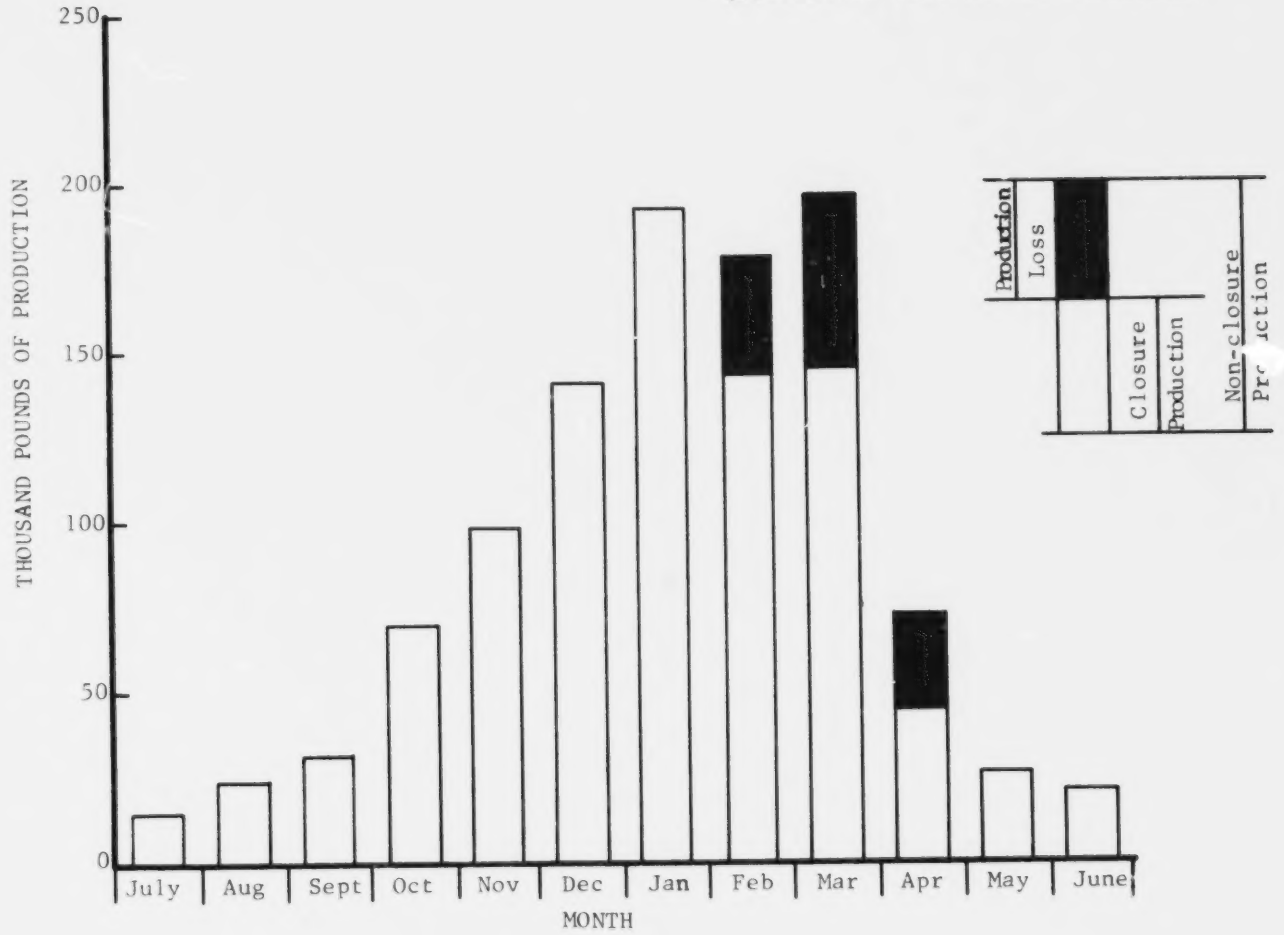


TABLE IV

OPENING AND CLOSING DATES OF OYSTER HARVESTING AREAS (7)*

	CLOSED	OPENED
1952	March 8	
1953	March 22	
1954	Not Closed	October 21
1955	January 14	August 30
1956	April 6	August 28
1957	May 7	September 1
1958	Not Closed	
1959	Not Closed	
1960	Not Closed	
1961	December 31	
1962		September 1, April 11
1963		
1964	March 30	
1965	March 15, February 22	April 9
1966	March 6	April 2
1967		
1968	January 12	March 4

*The Alabama Water Improvement Commission indicated that all closures during May, June, July August were for conservation purposes.

TABLE V

OYSTER HARVESTING BY SEASON*
Mobile Bay, 1954-1967

SEASON	Harvest in Thousands of Pounds	
	Open Season	Closed Season Due to Pollution
1967-68		798**
1966-67	2,297	
1965-66		751
1964-65		442
1963-64		1,339
1962-63	631	
1961-62		401
1960-61	799	
1959-60	1,225	
1958-59	555	
1957-58	571	
1956-57	1,270	
1955-56	847	
1954-55		1,760

Average Harvest = 1,024,000 #/year open season
915,000 #/year closed season

Net Loss in Harvest = 109,000 #/year = 10.7%

*This table was constructed from monthly harvest figures for Mobile and Baldwin Counties provided by the Bureau of Commercial Fisheries, New Orleans, Louisana.

**Covers July 1967 to March 1968.

TABLE VI

OYSTER HARVESTING VARIATION AS RELATED TO POLLUTION CLOSURES

Average Monthly Harvest
(in 1000 of Pounds)
(covers 1954-55 to 1966 to 1967 Period and July to February of 1968 Period)

Month	Average Mo. Harvest Open Periods	Average Mo. Harvest Closed Periods	Harvesting Loss	Percent Loss	Estimated Average Economic Loss* (due to pollution)
July	All closures in this month were for conservation purposes				
August	All closures in this month were for conservation purposes				
September	33	No closures occurred during this month			0
October	71	No closures occurred during this month			0
November	100	No closures occurred during this month			0
December	142	No closures occurred during this month			0
January	188	193	0	0	0
February	179	144	35		18,200
March	197	146	51		26,500
April	73	45	28		14,600
May	All closures in this month were for conservation purposes				
June	All closures in this month were for conservation purposes				

*Based on an average January 1969 as-landed price of $0.52 per pound.

Average annual shellfish harvests during the seasons with no pollution closures were 1,024,000 pounds. During seasons when closures were in effect, the average harvest was 915,000 pounds. Based on the average January 1969 price per pound as-landed of $0.52, the 109,000 pounds per year lost due to pollution closure had an average as-landed value of $56,700. These values indicate losses over a relatively long period of time, but do not consider differences in seasonal production. The landings data were broken down to describe monthly production over the 1954-55 to 1966-67 season period. Production values during closed and open months, and fractions thereof were determined.

Table VI shows average monthly oyster harvest values during open and closed periods over the period under study. An anomaly is observed for January where landings are greater during the closed period than the open period. This is attributed to the 1954-55 producing season when 525,000 lbs of oysters were harvested in January. Even though the beds were closed for over two weeks the production was so great that the closure effect upon production is apparently masked. The value is the highest January production over the period of study. The above values are generally considered as conservative since they deal with Mobile Bay as an entire unit. Closures, however, generally affect Mobile County oyster harvesters to a greater extent than Baldwin County harvesters since closures generally do not extend to Bon Secour Bay (in Baldwin County) which is a significant oyster producing area. Thus, when Mobile Bay is closed, only the Mobile County side is affected. (All of Mobile Bay, including Bon Secour Bay, was closed for the first time in 1968). When closures are applied, Mobile County oyster harvesters do not generally go to Bon Secour Bay to harvest,

but may look to Portersville Bay as a source of oysters. Portersville Bay, while a productive area, is no substitute for the productive beds of lower Mobile Bay.

As shown in Table VI, the average monthly harvesting loss when closures are in effect can be quite substantial. The respective average harvesting losses during the months when pollution closures have been in effect are 35,000 pounds in February, 51,000 pounds in March, 28,000 pounds in April. The corresponding economic losses based on an as-landed value of $0.52 per pound averaged for January 1969 in Mobile and Baldwin Counties are $18,200 in February, $26,500 in March, and $14,600 in April.

The as-landed value of oysters reported by the Bureau of Commercial Fisheries is that amount received by harvesters. In a study conducted by Florida State University, it was indicated that the true value of oysters to the community under study, after processing and distribution, was about four times that amount.(9) Studies conducted by the Georgia Agricultural Experiment Station indicate that a multiple of 3.5 can be applied to oysters as-landed values to reflect retail values.(10) Thus, the total economic loss could be a factor of four greater than the loss based on the as-landed value and could conceivably approach $227,000 per year.

V. WASTE SOURCES

A. Municipal Wastes

Five municipalities - Chicksaw, Fairhope, Mobile, Prichard, and Saraland - have municipal sewerage systems including treatment plants. Chickasaw, with a lagoon-type treatment, and Fairhope and Saraland, each operating secondary plants, discharge into Chickasaw Creek, Mobile Bay, and Norton's Creek, respectively. Mobile operates five secondary plants discharging into Hall's Mill Creek, Eslava Creek, Mobile Bay (two plants), and Three Mile Creek. Prichard has two secondary plants, one discharging into Eight Mile Creek and the other discharging to Three Mile Creek. All plants except the lagoon serving Chickasaw are equipped with facilities for chlorinating treated wastes. Mobile's plant on Eslava Creek has reached its capacity and must be expanded for treating further increases in sewage from the area served by this plant.

The only portion of a municipal sewerage system in the basin from which untreated sewage is being discharged is the downtown area of Mobile. A project has been approved for these sewers to be intercepted and sewage routed to Mobile's McDuffie Island sewage treatment plant. Secondary sewage treatment will be installed for a privately-owned system serving Alabama Dry Docks on Blakely Island, now discharging untreated sewage into Mobile River. These two untreated sources serve approximately 7,000 people.

Privately-owned systems serving Spanish Fort Estates and Windsor Square in Baldwin County are equipped with secondary treatment plants discharging into D'Olive Creek and Blakely River. Searcy Hospital, a unit of the Alabama State Hospital system at Mt. Vernon, and Mobile College discharge sewage after secondary treatment through stabilization lagoons to Cedar Creek and Chickasaw Creek, respectively. There is a need for community sewage systems and treatment facilities in Bayou La Batre, Daphne, and Satsuma to replace septic tanks serving individual homes. There is a secondary sewage treatment plant serving Dauphin Island.

B. Industrial Wastes

The paper mills of International Paper Company and Scott Paper Company are the largest contributors of industrial wastes in the basin. Both dishcarge into the lower part of Chickasaw Creek adjacent to each other. Within the past few years, Scott Paper Company has constructed secondary treatment facilities while International Paper Company has provided primary treatment for its industrial waste since 1957. Domestic waste is treated in a septic tank. Scott Paper Company, however, operates the secondary facilities only in the summer and uses primary treatment during the remainder of the year. Half of the domestic wastes is treated with the industrial wastes and half is discharged into the municipal system. National Gypsum Company discharges wastes into Garrows Bend, Mobile Bay, without treatment and has been notified by the Alabama Water Improvement Commission that treatment will be required. Haas-Davis Packing Company was discharging untreated wastes from its meat processing plant into a branch a short distance from Three Mile Creek. This company has recently complied with the order

of the Alabama Water Improvement Commission to arrange for the wastes to be treated through a municipal sewage treatment plant. Stone Container Corporation discharges waste into Three Mile Creek. Additional treatment is being required by the Alabama Water Improvement Commission to remove the color of this waste. Aluminum Company of America operates an essentially closed waste system for which water is returned to the plant for reuse following removal of solids in settling basins on Blakely Island. Seepage through the dikes of these basins and releases to avoid overflowing of the dikes during periods of heavy rainfall have, in the past, resulted in increases of alkalinity in Polecat Bay and a reddish color in waters of the Bay. The Alabama Water Improvement Commission has reported that improvements accomplished during 1967 eliminated the need for emergency releases from the basins and now provide for return of seepage to the basins.

Stauffer Chemical Company discharges wastes into Cold Creek under controlled conditions set by the Alabama Water Improvement Commission. Courtaulds North America discharges wastes into the Mobile River through an underwater diffuser near Twenty-Seven Mile Bluff, also under conditions established by the Commission.

Diamond Alkali Company discharges waste from a retention basin into the upper end of Hog Bayou, a tributary to Chickasaw Creek. Wastes from Linde Division of Union Carbide Corporation are discharged, after settling and blending, into the canal carrying the cooling water discharge from Alabama Power Company's Chickasaw steam plant, which in turn empties into Chickasaw Creek. Waste disposal practices of

these two companies are considered to be adequate by the Alabama Water Improvement Commission.

American Bitumals Company's plant on Blakely Island is a potential source, but has reportedly maintained control over its oil-bearing wastes to avoid water pollution. Although Ruberoid Company discharges the major portion of its wastes into Mobile's sanitary sewerage system, part of the water used by the company reaches a ditch flowing into Woodcock Branch. At times in the past, this waste has contained material which imparted a white color to the water. The present status of this situation is undetermined, although complaints regarding colored waste have not been received for some time.

Over four years ago, waters along the Baldwin County shore of Mobile Bay were visibly affected by disturbance of the bottom of Mobile Bay by dredging for the removal of oyster shells. Such operations have been restricted to distances sufficiently far away from the shore to prevent interference with the quality of in-shore waters.

Data available in the files of the Alabama Water Improvement Commission show that gross pollution is occurring in Bayou La Batre as a result of the discharge of untreated wastes from several seafood processing plants in the area. Dissolved oxygen in the Bayou has been reported by the Commission to be zero, and a significant fish kill on June 30, 1967 was attributed to these wastes. Several smaller kills have been reported by the Commission. A partial listing of these plants in the Bayou La Batre area has

been provided by the Alabama Water Improvement Commission and are: Bryant's Seafood Company, Inc.; Graham Seafood Company; Independent Seafood Company; Jerry's Seafood Company; Joe's Seafood Company, Inc.; Laforce Seafood Company; Lyons Seafood Company; Quality Foods, Inc.; Ramos Shrimp Company; Seafood Haven, Inc.; Seaman Fisheries, Inc.; Sea Pearl Seafood Company; Snake Bayou Seafood Company; Southland Shrimp Company; Steele Seafood Company; Stork Seafood Company; Water Front Seafood Company; and Horton Seafood Company.

In summary, the major organic waste producing industries not connected to the municipal system are International Paper Company; Scott Paper Company; Courtaulds North America, Incorporated; National Gypsum Company; and Stone Container Company. It is estimated that these industries discharge a total of approximately 116,000 pounds per day of five-day biochemical oxygen demand, a measure of organic concentration. On an organic demand basis, about 95% of the total waste discharges in the Mobile area are of industrial origin. None of the industrial waste sources employ chlorination or other means of disinfection. The domestic wastes produced by these industries generally receive septic tank treatment without chlorination.

Municipal and industrial waste sources are summarized in Table VII.(11)

TABLE VII

WASTE SOURCES

MOBILE RIVER AND MOBILE BAY

Location	Treatment	Flow (MGD)	Year Constructed	Receiving Stream
A) Municipal Waste				
Chickasaw	Lagoon	0.80	1964	Chickasaw Cr.
Dauphin Is.	Secondary-Chlorination	0.15	1957	Bay Aloe
Fairhope	Secondary-Chlorination	0.35	1950	Mobile Bay
Mobile				
1) McDuffie	Secondary-Chlorination	6.50	1958	Mobile Bay
2) Eslava Cr.	Secondary-Chlorination	4.00	1954	Eslava Cr.
3) Halls Mill Cr.	Secondary-Chlorination	0.50	1963	Halls Mill Cr.
4) Bill Ziebach	Secondary-Chlorination	0.50	1966	Mobile Bay
5) Three Mile Cr.	Secondary-Chlorination	5.50	1964	Three Mile Cr.
6) River Front	None	0.90		Mobile Bay
Prichard				
1) Grover St.	Secondary-Chlorination	2.00	1968	Three Mile Cr.
2) Eight Mile Cr.	Secondary-Chlorination	1.00	1962	Eight Mile Cr.
Saraland	Secondary-Chlorination	0.10	1963	Norton Branch

TABLE VII - CONT'D

WASTE SOURCES

MOBILE RIVER AND MOBILE BAY

Location	Treatment		Flow (MGD)	Receiving Stream
	Sewage	Industrial		
B) Industrial Waste				
American Bituminals	Septic Tank	Oil Recovery	1.05	Mobile R.
Courtaulds	Imhoff	Screening	6.14	Mobile R.
Diamond Alkali	Septic Tank	Storage Basins	0.30	Chickasaw C.
Haas Davis Packing	Municipal System		0.28	Three Mile C.
International Paper	Septic Tank	Settling Tank	31.73	Chickasaw C.
Scott Paper	Half to Munic. System Half to Indus. Wastes	Secondary(summer) Primary (winter)	59.74	Chickasaw C.
Nat'l. Gypsum Co.	Septic Tank	Primary	1.00	Mobile B.
Union Carbide - Linde Division	Septic Tank	Primary	0.60	Chickasaw C.
Stone Container Corp.	--	--	0.40	Three Mile Cr.

VI. WATER QUALITY

The major damage to water use in Mobile Bay caused by poor water quality is curtailment of shellfish harvesting during the winter and early spring months due to bacterial concentrations, specifically coliform organisms which exceed the level recommended by the U. S. Public Health Service and adopted as a standard by the State of Alabama. The coliform organisms have traditionally been used as indicators of pollution and of the possible presence of pathogens due to the difficulty of isolating the pathogens themselves. A major reservation associated with the use of the total number of coliform organisms as an indicator is that one of the principal species, Aerobacter aerogenes, has been shown to be ubiquitous and not necessarily confined to situations where there are identifiable pollutional discharges. In 1961, a laboratory procedure was devised for the separation of the coliform group into its environmental source components those of fecal orgin and non-fecal origin. The fecal coliform group is representative of the coliforms associated with warmblooded animal excreta.(12) Therefore, the fecal coliform group is a more direct indicator than total coliform of relatively recent fecal pollution.

Coliform data in Mobile Bay and in the Mobile River above and below Mobile have been collected on a periodic basis since 1949, primarily during flood flow into the Bay when the shellfish beds are usually closed. Data have been evaluated for 1949, 1950, 1961, 1962 and 1967. All data except for 1967 were collected by the Alabama

Water Improvement Commission. The 1967 data were reported by the Southeastern Comprehensive Water Pollution Control Project of FWPCA. The 1949 and 1950 data represented conditions during which no treatment of wastes was provided at Mobile. The 1961-62 data are representative of an intermediate condition during which some sewage treatment, both domestic and industrial, was operating. The 1967 data were collected when all of the domestic wastes from Mobile and adjacent areas except 0.9 million gallons per day (MGD) out of 22.2 MGD were treated and chlorinated.

Figures 4 and 5 represent total coliform data collected from January to May, 1949, and January to March, 1950. These dates roughly encompass the high flow runoff periods for those years. Combined flows in the Alabama and Tombigbee Rivers averaged 150,400 cubic feet per second (cfs) in 1949 and 110,600 cfs during 1950. Total coliform concentrations in the Mobile River above waste sources at Mobile had a median value of 430/100 ml during the 1949 period. There are no known major waste sources of bacteriological pollution above this point. In the Mobile River channel at the lower end of Pinto Island just above the Bay and below waste sources, total coliform densities were 11,000/100 ml, a 26-fold increase. The Tensaw River, the other major tributary at the head of Mobile Bay, had a median density of 240/100 ml at the mouth. There are no significant sources of organic wastes on the Tensaw River. Lines of equal coliform concentrations in the Bay (isolines) indicate that there is a "tongue" effect generally conforming to the channel area with increased lateral dispersion as longitudinal distance down the Bay increases.

FIGURE 4

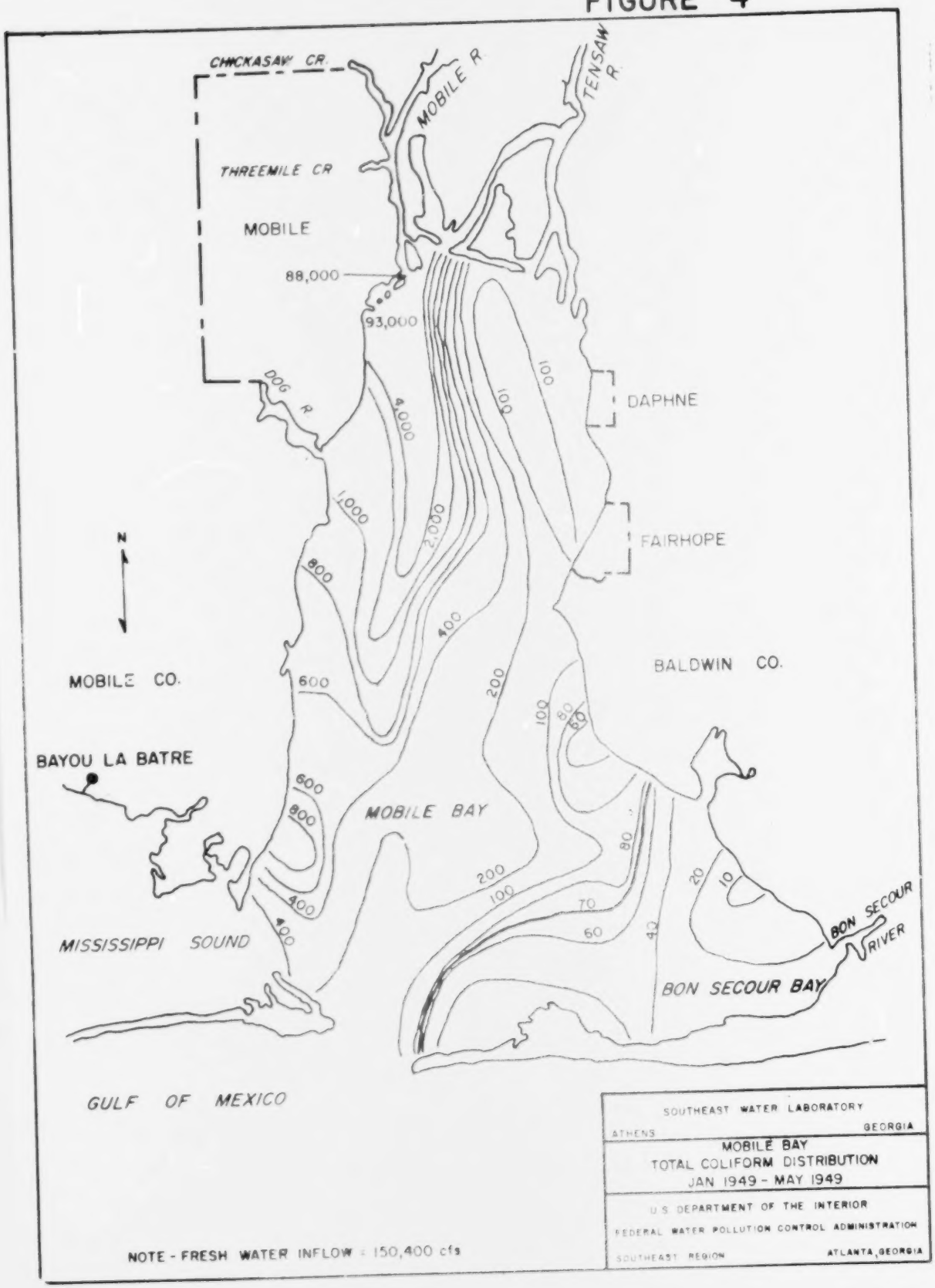
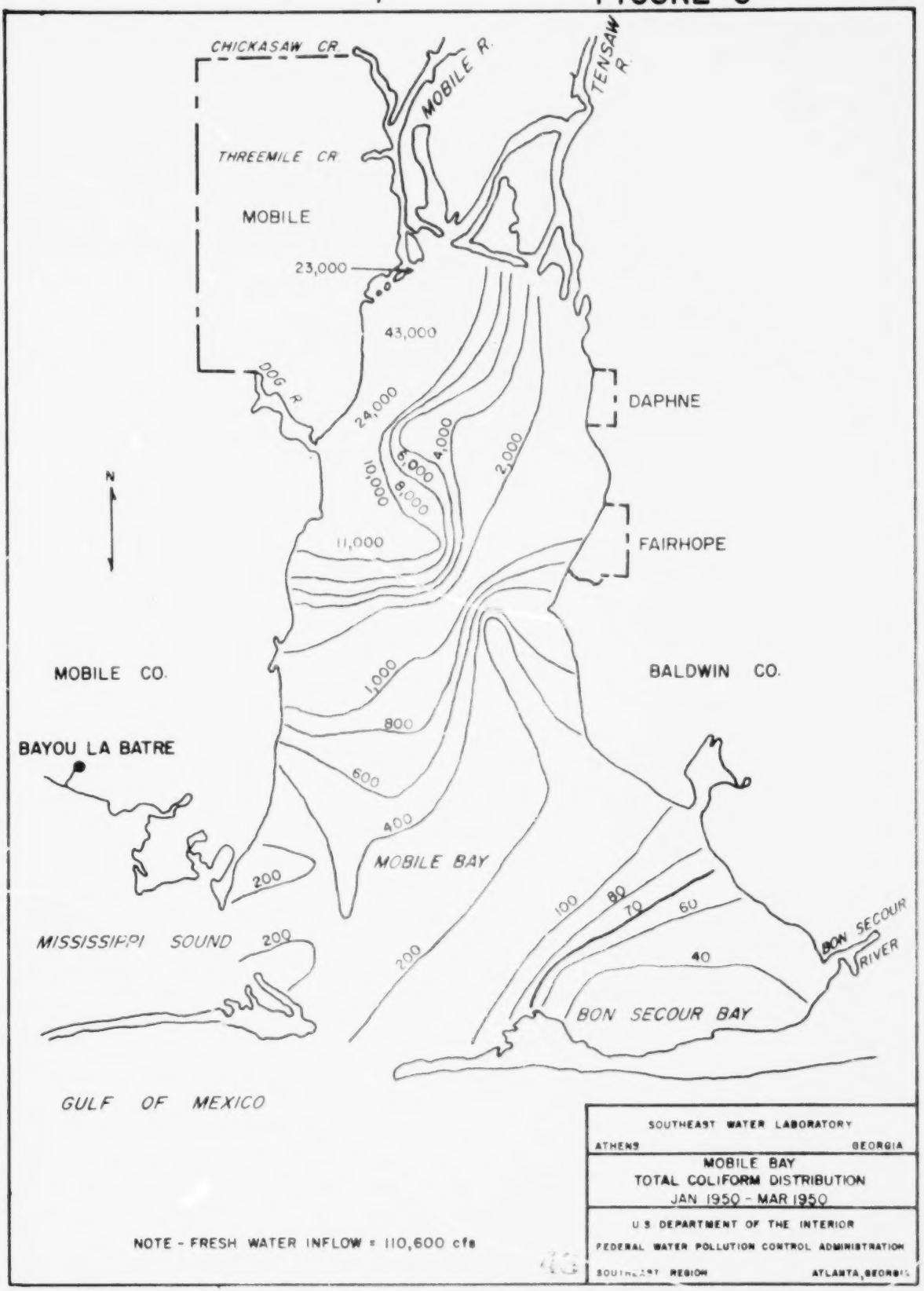

CHICKASAW CR.
MOBILE R.
TENSAW R.
THREEMILE CR
MOBILE
88,000
93,000
DOG R.
DAPHNE
FAIRHOPE
N
MOBILE CO.
BALDWIN CO.
BAYOU LA BATRE
MOBILE BAY
MISSISSIPPI SOUND
BON SECOUR RIVER
BON SECOUR BAY
GULF OF MEXICO
4,000
1,000
2,000
800
400
600
200
100
80
60
40
20
10
NOTE - FRESH WATER INFLOW = 150,400 cfs
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
MOBILE BAY
TOTAL COLIFORM DISTRIBUTION
JAN 1949 - MAY 1949
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

FIGURE 5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TENSAW R.
THREEMILE CR.
MOBILE
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43,000
DOG R.
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10,000
8,000
6,000
4,000
2,000
DAPHNE
FAIRHOPE
N
11,000
MOBILE CO.
BALDWIN CO.
1,000
800
600
400
200
BAYOU LA BATRE
MOBILE BAY
MISSISSIPPI SOUND
200
200
100
80
70
60
40
BON SECOUR RIVER
BON SECOUR BAY
GULF OF MEXICO
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
MOBILE BAY
TOTAL COLIFORM DISTRIBUTION
JAN 1950 - MAR 1950
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA
NOTE - FRESH WATER INFLOW = 110,600 cfs

Densities in the approved shellfish areas ranged from about 200/100 ml to 1,000/100 ml. Median concentrations in the entire Bay exceeded 70/100 ml except for a portion of Bon Secour Bay. There was, however, an unusual distribution of coliform in the area offshore of Mon Louis Island in the vicinity of some of the most active shellfishing areas. This anomaly cannot be explained in terms of a regular dieaway or dilution of waste resulting from the Mobile River and may indicate a possible additional source of coliform. There are no significant waste sources in the immediate area to account for this phenomenon.

During the high flow period of 1950, the median density above Mobile in the Mobile River was 750/100 ml. Below Mobile, at the mouth of the River, the density had increased to 23,000/100 ml, or 31 times greater. The concentration in the Tensaw River during this period was 430/100 ml. As in 1949, the pattern of coliform concentration in Mobile Bay showed high densities inflowing from the Mobile River and generally demonstrated a distribution of the highest values in the channel and along the western shore to a point south of the Dog River. Median densities of as high as 43,000/100 ml were observed. Below this point, there was a sharp decrease. However, concentrations in the shellfish areas again ranged from about 200/100 ml to 1,000/100 ml. Fresh water flow during this period averaged about 73% of the previous year high runoff.

From mid-February to mid-April, 1961, the flood runoff to the Mobile River from the Alabama and Tombigbee Rivers averaged 275,000 cfs, a record. Total coliform density in the Mobile River from above to below the Mobile area increased over four times from 3,400/100 ml to 15,000/100 ml. Median density in the Tensaw River was 930/100 ml.

At this time, secondary treatment and chlorination had been applied to 62% of the total domestic wastes. Again, the highest concentrations were in the channel and along the western shore of the Bay. Densities in the shellfishing areas ranged from approximately 800/100 ml to 4,000/100 ml. The same unusual distribution off the southern end of Mon Louis Island was again apparent as in the 1949 data. Total coliform densities in this area were about 4,000/100 ml. Fecal coliform medians exhibited the same general distribution pattern. Densities increased over four times in the Mobile River from above to below Mobile. The respective concentrations were 330/100 ml and 1,370/100 ml. The corresponding density in the Tensaw River was 93/100 ml. Fecal densities in the shellfishing areas ranged from 80/100 ml to 300/100 ml. A concentration of 7.8/100 ml was exceeded in all sections of Mobile Bay and Bon Secour Bay. Total and fecal coliform distributions are shown in Figures 6 and 7.

From late December, 1961, to late April, 1962, the mean combined flow of the Alabama and Tombigbee Rivers was about 165,000 cfs. Total coliform medians increased sixteen times from 9,300/100 ml below the confluence of the Alabama and Tombigbee Rivers in the Mobile River to 150,000/100 ml at the mouth. Fecal coliform medians for the same points increased two and one-half times from 930/100 ml to 2,300/100 ml. Total and fecal medians in the Tensaw River were 4,300/100 ml and 430/100 ml, respectively. Isolines indicated the same distribution pattern as the previously discussed data, including the anomalous concentrations off Mon Louis Island for both total and fecal coliforms. Densities in this area were 4,000/100 ml for total coliform and

FIGURE 6

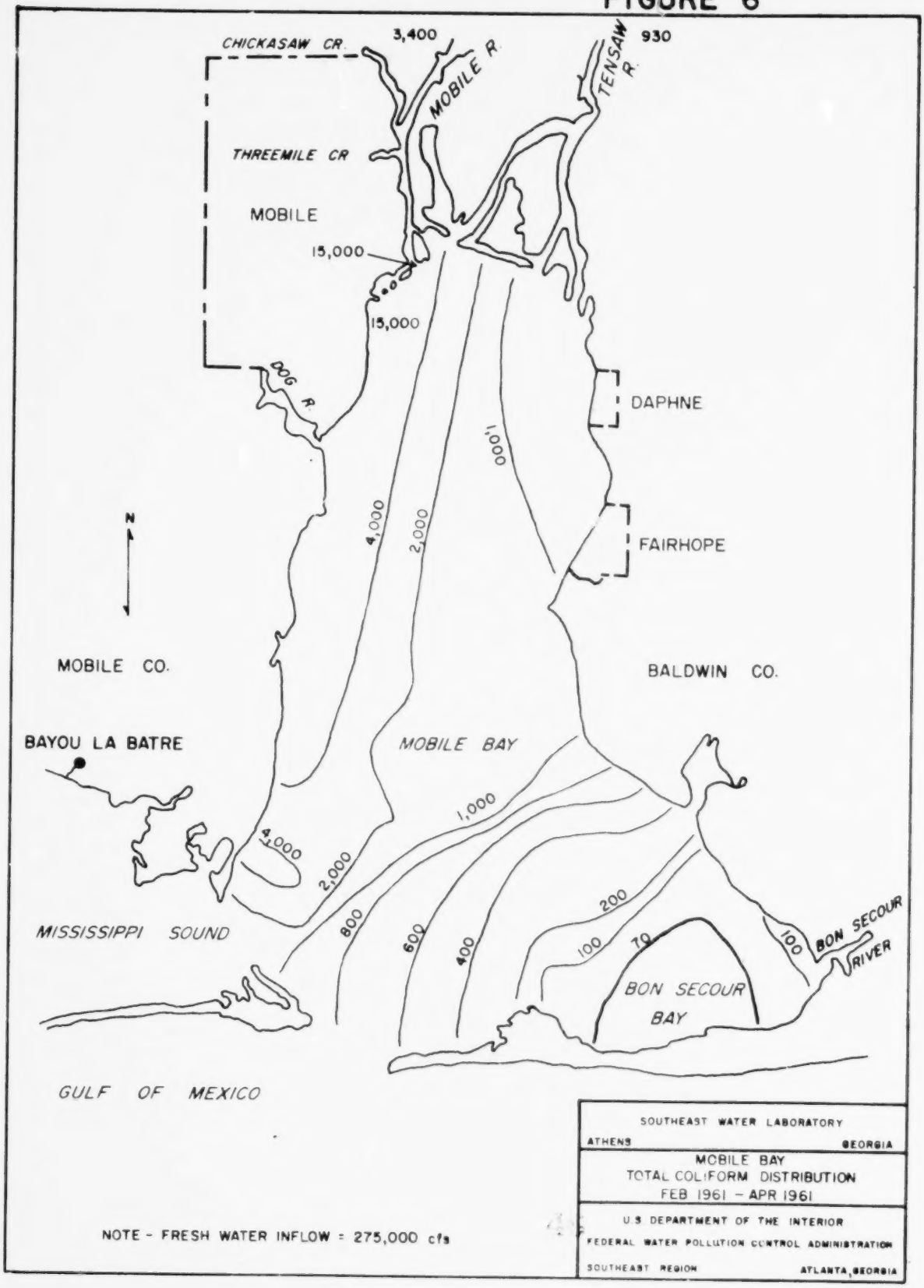
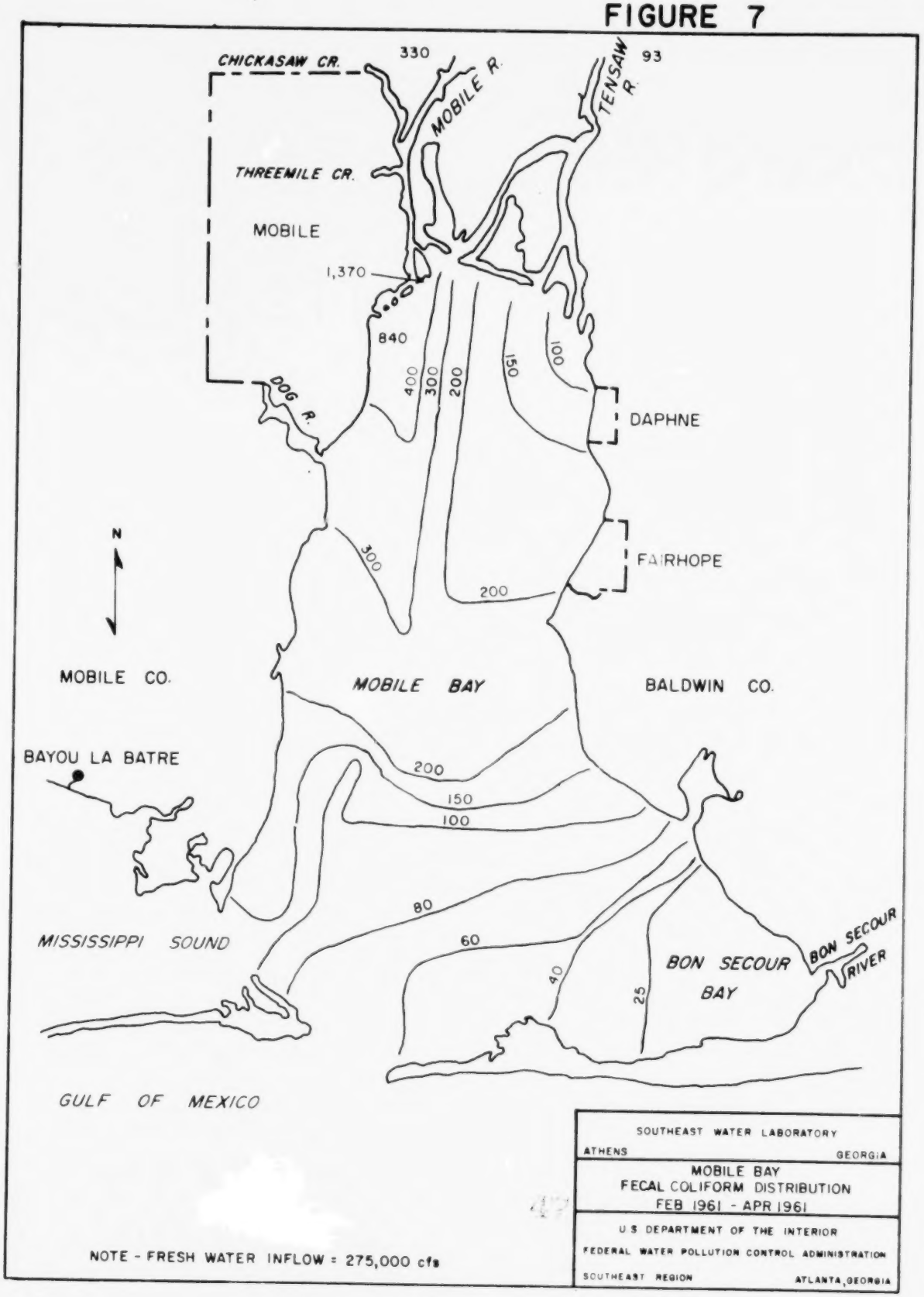

CHICKASAW CR.
3,400
MOBILE R.
TENSAW R.
930
THREEMILE CR
MOBILE
15,000
15,000
DOG R.
DAPHNE
1,000
4,000
2,000
FAIRHOPE
N
MOBILE CO.
BALDWIN CO.
BAYOU LA BATRE
MOBILE BAY
1,000
4,000
2,000
800
600
400
200
100
70
100
BON SECOUR RIVER
MISSISSIPPI SOUND
BON SECOUR BAY
GULF OF MEXICO
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
MOBILE BAY
TOTAL COLIFORM DISTRIBUTION
FEB 1961 - APR 1961
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA
NOTE - FRESH WATER INFLOW = 275,000 cfs

FIGURE 7


CHICKASAW CR.
330
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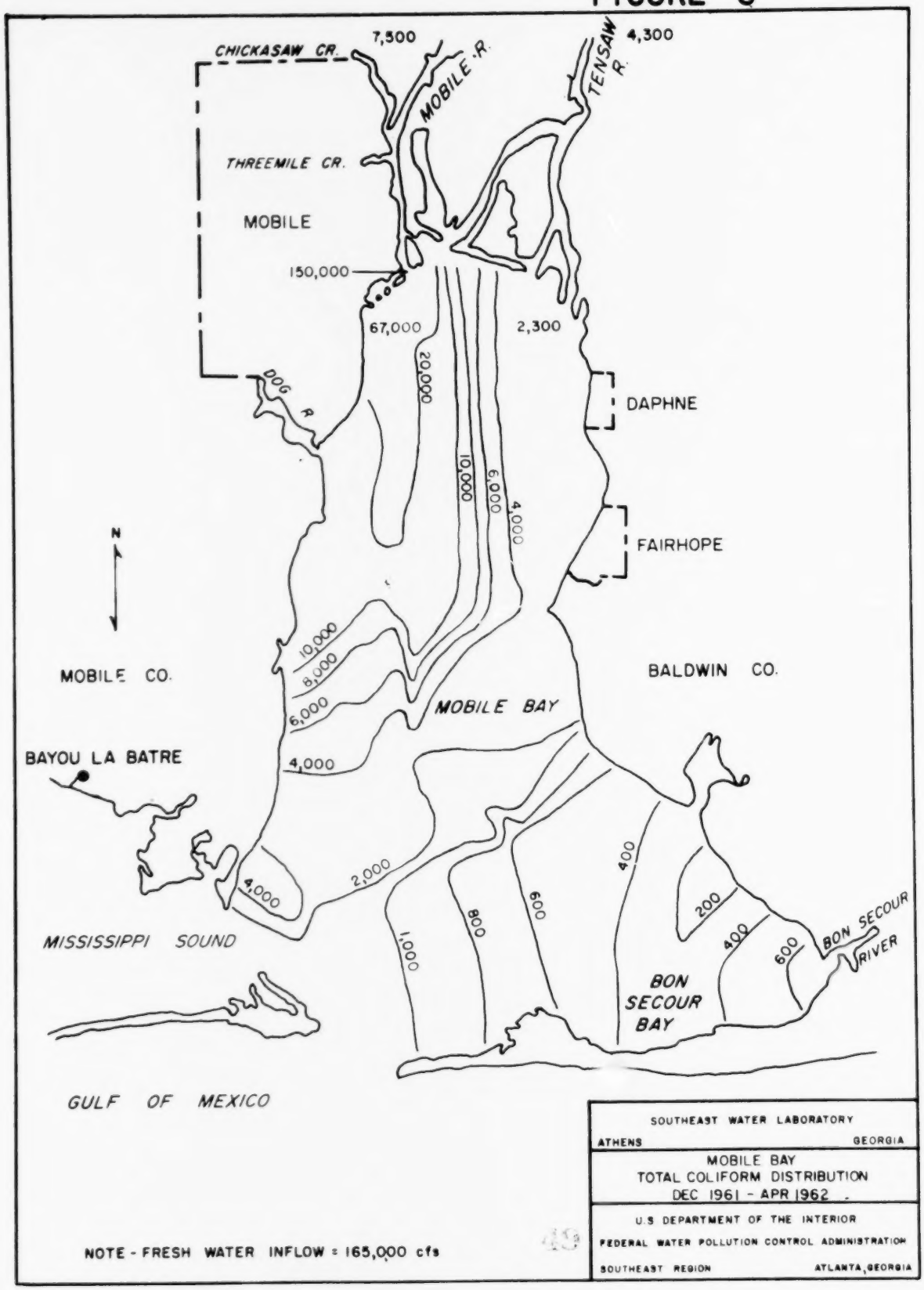
TENSAW R.
93
THREEMILE CR.
MOBILE
1,370
840
400
300
200
150
100
DOG R.
DAPHNE
FAIRHOPE
N
300
200
MOBILE CO.
MOBILE BAY
BALDWIN CO.
BAYOU LA BATRE
200
150
100
80
60
40
25
MISSISSIPPI SOUND
BON SECOUR BAY
BON SECOUR RIVER
GULF OF MEXICO
NOTE - FRESH WATER INFLOW = 275,000 cfs
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
MOBILE BAY
FECAL COLIFORM DISTRIBUTION
FEB 1961 - APR 1961
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

approximately 100/100 ml for fecal coliform. Total and fecal coliform distributions are shown ir Figures 8 and 9.

From December, 1966, to March, 1967, the average flood flow in the Mobile River approximated 73,500 cfs. Coliform concentrations remained relatively constant at several points in the Mobile River, from river mile (RM) 44.5 to RM 7, having median values ranging between 3,300/100 ml and 4,900/100 ml total coliform and 90/100 ml to 460/100 ml fecal coliform. In the Mobile River immediately above Chickasaw Creek, total and fecal coliform median densities were 3,300/100 ml and 90/100 ml, respectively. Below Chickasaw Creek and above Three Mile Creek, the respective toral and fecal coliform densities were 6,400/100 ml and 490/100 ml. Waste discharges into Chickasaw Creek and its tributaries, Eight Mile Creek and Hog Bayou, include the unchlorinated domestic effluent from the lagoons serving Mobile College and Chickasaw; chlorinated effluent from Prichard; and the primary treated effluents from Scott Paper Company, International Paper Company, and Diamond Alkali Company. Below Three Mile Creek, total and fecal coliform had increased to 13,200/100 ml and 1,400/100 ml . Three Mile Creek at this time was receiving untreated wastes from the Haas Davis Packing Company, chlorinated waste from Mobile, and primary treated, unchlorinated waste from Prichard. Haas Davis has recently connected to the Mobile sewer system. The section of the Mobile River from below Three Mile Creek to the mouth receives untreated waste from the downtown area and from the Alabama State Docks. At the mouth of the Mobile River, the total coliform median was approximately 29,500/100 ml and the fecal coliform median was 1,400/100 ml. This represents an eight-

FIGURE 8


CHICKASAW CR.
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MOBILE R.
TENSAW R.
4,300
THREEMILE CR.
MOBILE
150,000
67,000
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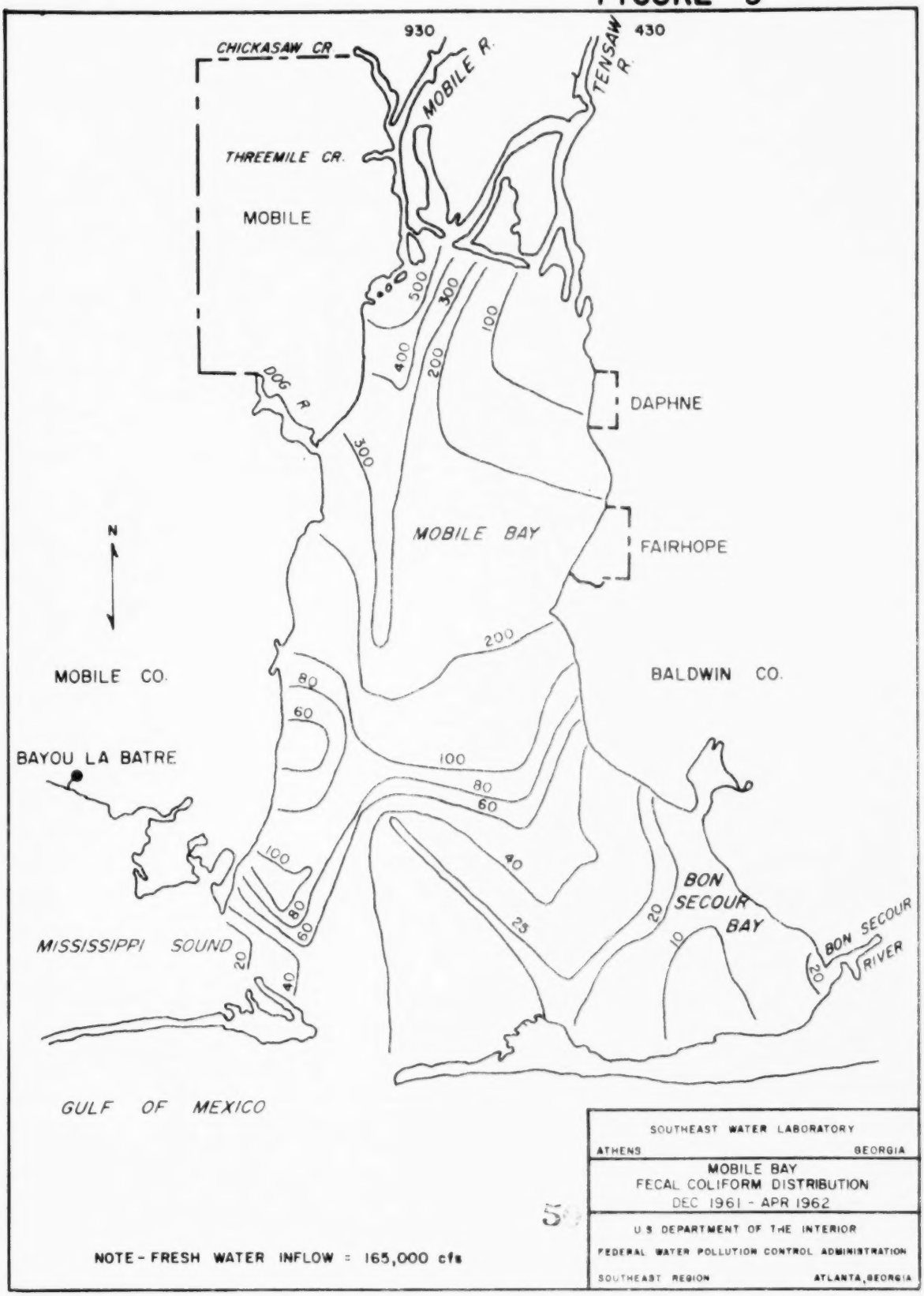
20,000
10,000
6,000
4,000
DOG R.
DAPHNE
FAIRHOPE
N
MOBILE CO.
BALDWIN CO.
MOBILE BAY
10,000
8,000
6,000
4,000
BAYOU LA BATRE
4,000
2,000
1,000
800
600
400
200
400
600
BON SECOUR RIVER
BON SECOUR BAY
MISSISSIPPI SOUND
GULF OF MEXICO
NOTE - FRESH WATER INFLOW = 165,000 cfs
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
MOBILE BAY
TOTAL COLIFORM DISTRIBUTION
DEC 1961 - APR 1962
U.S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

FIGURE 9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TENSAW R.
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THREEMILE CR.
MOBILE
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300
100
400
200
DOG R.
DAPHNE
300
MOBILE BAY
FAIRHOPE
N
200
MOBILE CO.
BALDWIN CO.
80
60
BAYOU LA BATRE
100
80
60
100
40
80
60
BON SECOUR BAY
MISSISSIPPI SOUND
20
23
20
10
BON SECOUR RIVER
20
40
GULF OF MEXICO
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
MOBILE BAY
FECAL COLIFORM DISTRIBUTION
DEC 1961 - APR 1962
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA
NOTE - FRESH WATER INFLOW = 165,000 cfs

fold increase for total coliform and a nearly five-fold increase for fecal coliform from above to below the Mobile area. Total coliform medians in the Tensaw River were 4,900/100 ml at RM 40.7 and 2,300/100 ml at RM 11.5. Fecal coliform medians for the same points were 330/100 ml and 80/100 ml, respectively. Median total and fecal coliform densities at the mouth of Polecat Bay were 3,600/100 ml and 120/100 ml, respectively. Distribution in the Bay was as described previously. Data was not collected below a line south of Fairhope. Total coliform medians exceeded 2,000 per 100 ml and fecal coliform had a median of 100 per 100 ml along this line. The distributions of total and fecal coliform during the period are shown in Figures 10 and 11.

Coliform distribution in the Bay was evaluated during a low flow period to determine the relative effect of high flood inflows. From August to November, 1962, the average flow of the Alabama and Tombigbee Rivers to the Mobile River was 14,300 cfs. Under these flow conditions, total coliform medians increased in the Mobile River from above to below Mobile from 430/100 ml to 9,300/100 ml. Fecal coliform medians increased from 21/100 ml to 2,300/100 ml. This represents a 22-fold increase for total coliform and a 110-fold increase for fecal coliform. Isolines in the Bay showed a similar distribution of coliform as at high flow but with a less well pronounced "tongue" effect. In addition, the concentrations appear to disperse more regularly and the net direction is the center of the Bay, rather than along the western shore as in the high flow periods. There is also a sharper decrease with longitudinal distance down the Bay. With respect to the 70/100 ml standard, total coliform concentrations were acceptable

FIGURE 10

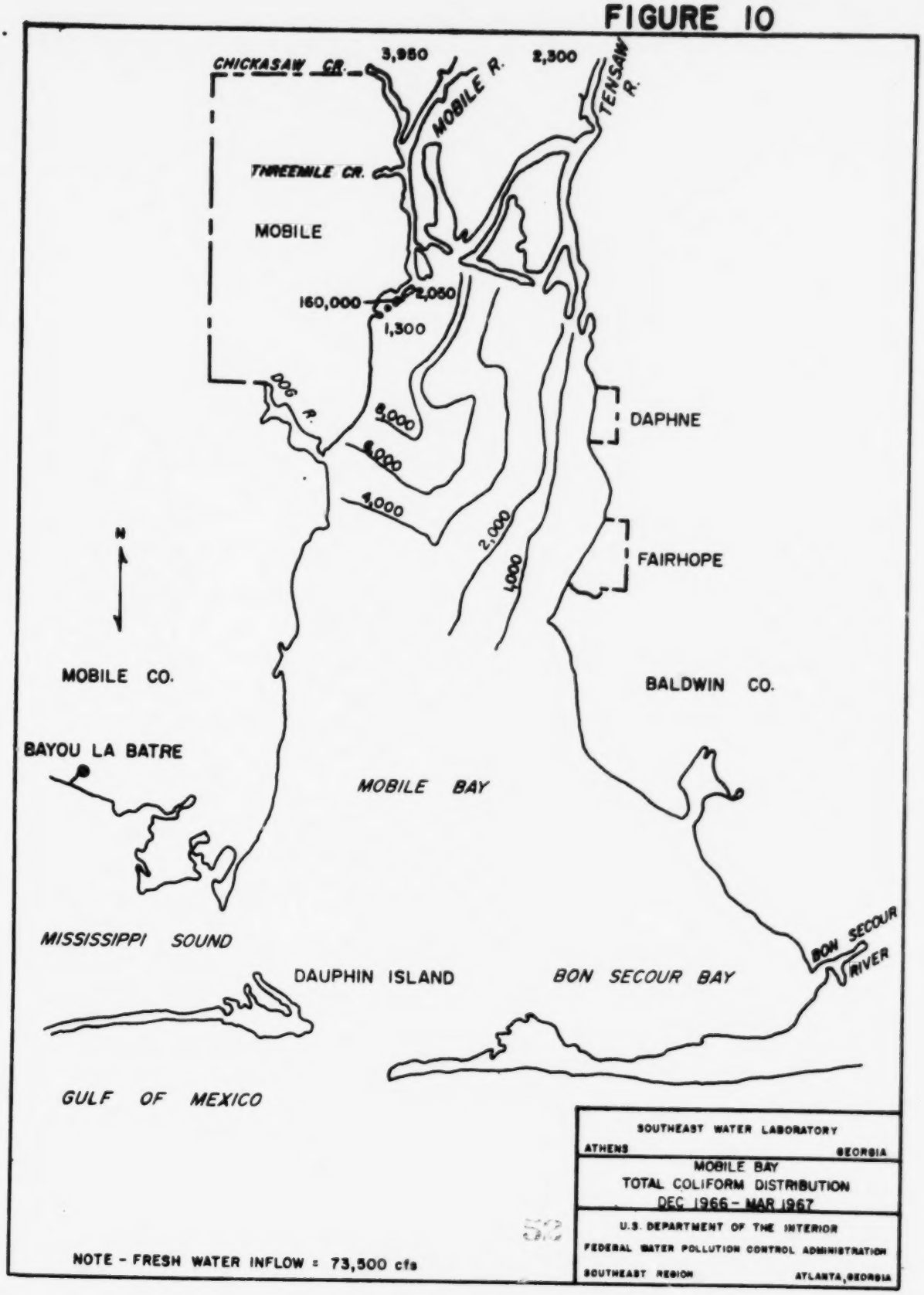
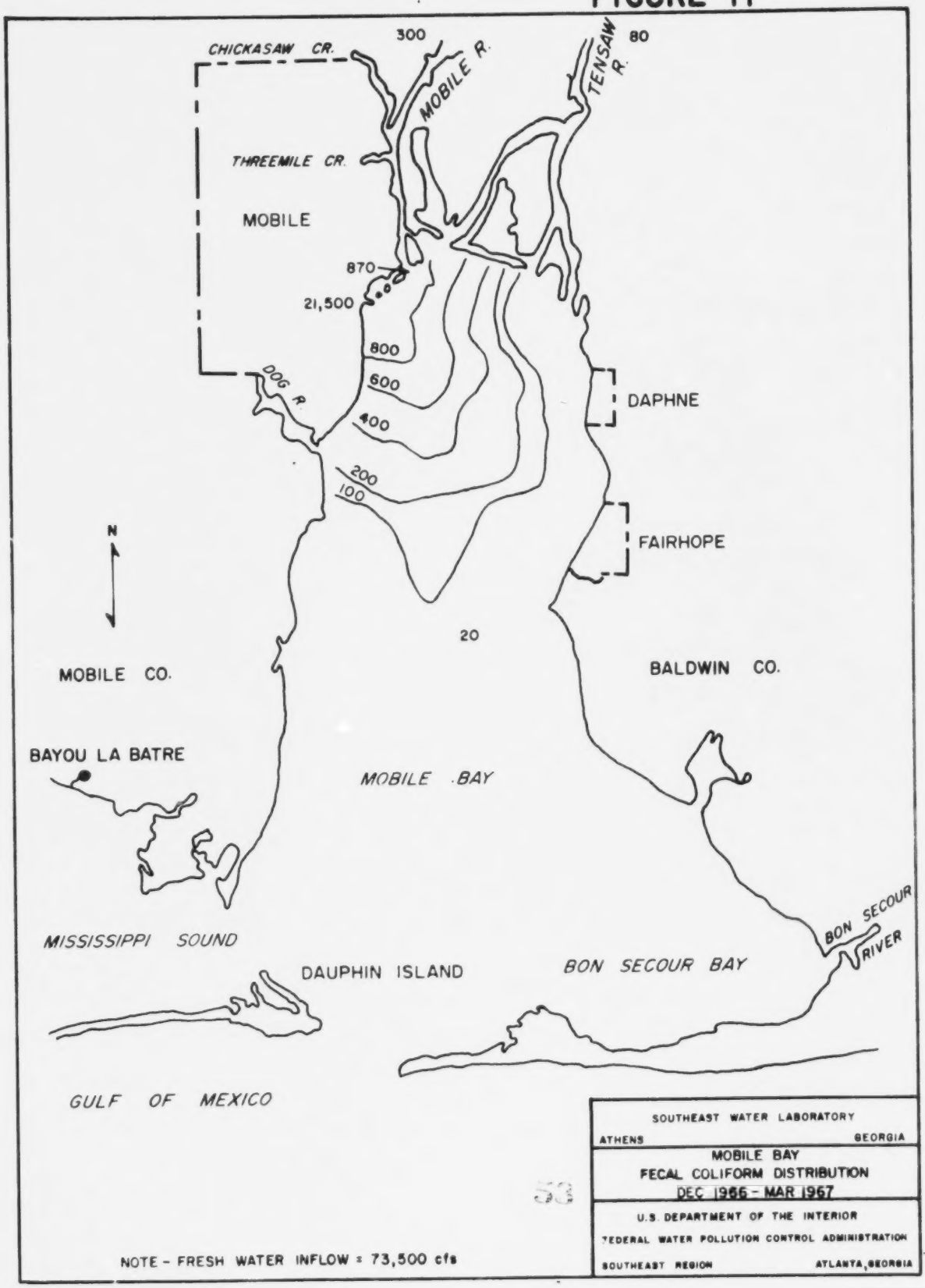

CHICKASAW CR.
3,950
MOBILE R.
2,300
TENSAW R.
THREEMILE CR.
MOBILE
160,000
2,050
1,300
DOG R.
3,000
8,000
4,000
2,000
1,000
DAPHNE
FAIRHOPE
N
MOBILE CO.
BALDWIN CO.
BAYOU LA BATRE
MOBILE BAY
MISSISSIPPI SOUND
DAUPHIN ISLAND
BON SECOUR BAY
BON SECOUR RIVER
GULF OF MEXICO
NOTE - FRESH WATER INFLOW = 73,500 cfs
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
MOBILE BAY
TOTAL COLIFORM DISTRIBUTION
DEC 1966 - MAR 1967
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

FIGURE 11


CHICKASAW CR.
300
MOBILE R.
TENSAW R.
80
THREEMILE CR.
MOBILE
870
21,500
800
600
400
200
100
DOG R.
DAPHNE
FAIRHOPE
N
20
MOBILE CO.
BALDWIN CO.
BAYOU LA BATRE
MOBILE BAY
MISSISSIPPI SOUND
DAUPHIN ISLAND
BON SECOUR BAY
BON SECOUR RIVER
GULF OF MEXICO
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
MOBILE BAY
FECAL COLIFORM DISTRIBUTION
DEC 1966 - MAR 1967
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA
NOTE - FRESH WATER INFLOW = 73,500 cfs

for shellfishing all along the eastern shore of the Bay and along the western shore below a line extending from south of Fairhope. Figures 12 and 13 illustrate the low flow total and fecal coliform distributions.

There are certain conclusions which may be drawn from consideration of these data concerning the excessive coliform densities in Mobile Bay. Table VIII summarizes the median coliform densities in the Mobile and Tensaw Rivers. The Mobile River is overwhelmingly the single most significant source of coliform pollution to Mobile Bay. The Tensaw River, the other major tributary, consistently has shown coliform concentrations at the mouth to be five to 53 times less than those of Mobile River at its mouth. In the Mobile River, during high flood runoff and at a time when sewage treatment and chlorination were being provided for a majority of the domestic wastes in the Mobile metropolitan area, 77 to 95 per cent of the total coliform and 60 to 79 per cent of the fecal coliform entering Mobile Bay was contributed from above to below Mobile. When no treatment or disinfection was provided, 96 to 97 per cent of the total coliform pollution was contributed from above to below Mobile during high flow periods. During the low flow period examined, the Mobile area contribution represented 95.5 per cent of the total coliform and 99 per cent of the fecal coliform in the Mobile River at the mouth.

It is apparent that, although there has been some improvement due to treatment and disinfection of municipal waste sources, there are still significant increases in coliform pollution, both total and fecal, from above to below the Mobile metropolitan area. Approximately 117 MGD of domestic and industrial wastes are discharged into the

FIGURE 12

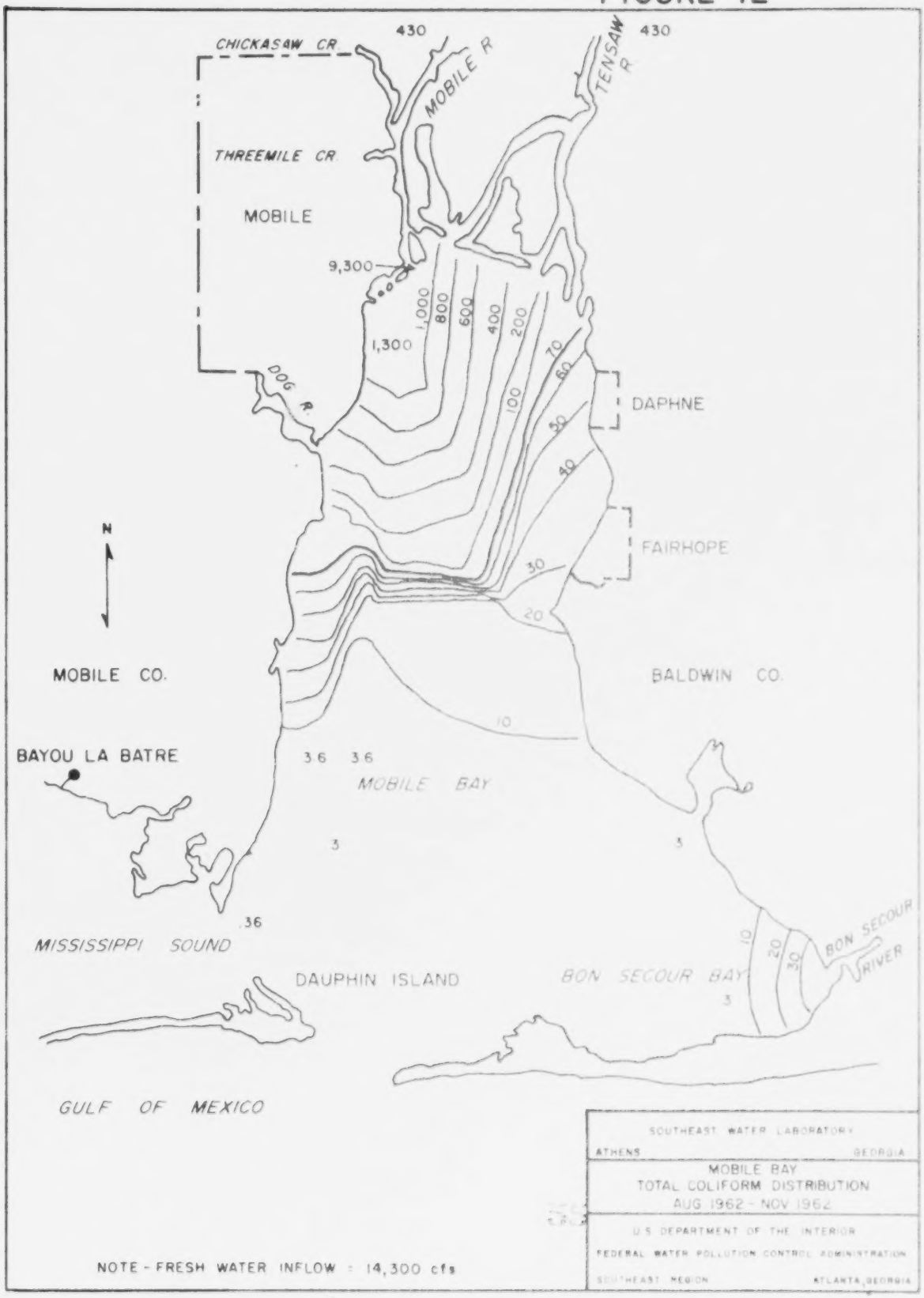
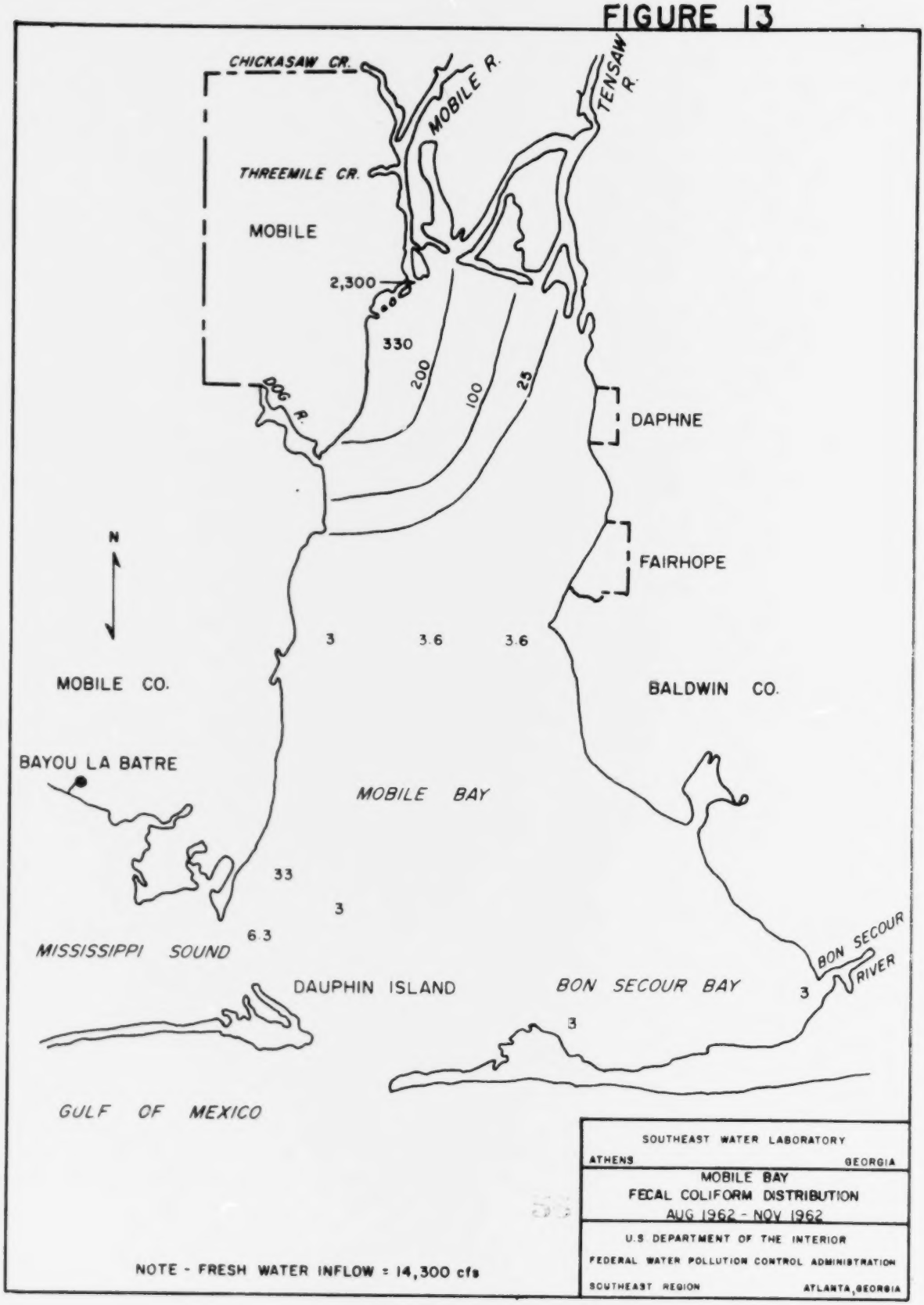

CHICKASAW CR
430
MOBILE R
TENSAW R
430
THREEMILE CR
MOBILE
9,300
1,000
800
600
400
200
70
60
100
1,300
DOG R
DAPHNE
50
40
N
FAIRHOPE
30
20
MOBILE CO.
BALDWIN CO.
10
BAYOU LA BATRE
3.6 3.6
MOBILE BAY
3
3
.36
MISSISSIPPI SOUND
10
20
30
BON SECOUR RIVER
DAUPHIN ISLAND
BON SECOUR BAY
3
GULF OF MEXICO
NOTE - FRESH WATER INFLOW = 14,300 cfs
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
MOBILE BAY
TOTAL COLIFORM DISTRIBUTION
AUG 1962 - NOV 1962
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

FIGURE 13


CHICKASAW CR.
MOBILE R.
TENSAW R.
THREEMILE CR.
MOBILE
2,300
330
200
100
25
DOG R.
DAPHNE
FAIRHOPE
N
3
3.6
3.6
MOBILE CO.
BALDWIN CO.
BAYOU LA BATRE
MOBILE BAY
33
3
6.3
MISSISSIPPI SOUND
DAUPHIN ISLAND
BON SECOUR BAY
BON SECOUR RIVER
3
3
GULF OF MEXICO
NOTE - FRESH WATER INFLOW = 14,300 cfs
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
MOBILE BAY
FECAL COLIFORM DISTRIBUTION
AUG 1962 - NOV 1962
U.S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

Station	Location	
Oyster Bed Sampling Stations - East of Dauphin Island Causeway		
	Latitude	Longitude
D5	30° 18.43'	88° 08.02'
D6	30° 18.20'	88° 07.89'
D7	30° 18.02'	88° 07.56'
D8	30° 17.84'	88° 07.85'
D9	30° 17.88'	88° 07.73'

TABLE VIII

MEDIAN COLIFORM DENSITIES - MOBILE AND TENSAW RIVERS

Period	Mobile R. Flow (cfs)	Above Mobile		Below Mobile		% Increase		Tensaw River	
		Total Coliform mpn/100ml	Fecal Coliform mpn/100ml	Total Coliform mpn/100ml	Fecal Coliform mpn/100ml	Total	Fecal	Total Coliform mpn/100ml	Fecal Coliform mpn/100ml
Jan.-May 1949	150,400	430	-	11,000	-	2,600	-	240	-
Jan.-March 1950	110,600	750	-	23,000	-	3,100	-	430	-
Feb.-April 1961	275,000	3,400	330	15,000	1,370	440	415	930	93
Dec.-April 1962	165,000	9,300	930	150,000	2,300	1,600	250	4,300	430
Dec.-March 1967	73,500	3,800	300	29,500	1,400	780	470	2,300	80
Aug.-Nov. 1962	14,300	430	21	9,300	2,300	2,160	11,000	-	-

Mobile River and tributaries. Of this total, about 80 per cent on a flow basis represents organic industrial wastes which are known to generally produce high total coliform concentrations. In fact, considering organic demand as the criterion, industrial wastes discharged amount to 95 per cent of the total. At high flows, waste loads are carried along the western shore of the Bay and reach the shellfishing areas before dieoff or dilution decreases the bacterial concentrations to acceptable levels. At the present time, concentrations during high flow periods are many times greater than the 70/100 ml median total coliform required for approved shellfish harvesting.

Studies by the Alabama Water Improvement Commission indicate that during high fresh water flows waters entering the Bay follow the western shore on a direct route to the oyster producing areas. The Commission has demonstrated that coliform densities increase as flow increases in the Alabama and Tombigbee Rivers. Data collected in the Tombigbee River near Leroy and the Alabama River near Claiborne continuously from 1960 to 1962 show that there is an imprecise direct correlation between flow and coliform concentrations, both total and fecal. As flow increases, coliform densities also increase. Therefore, at high flows, coliform densities throughout the bay will be higher irrespective of waste sources in the Mobile vicinity.

If the coliform contribution contributed at Mobile during high flow (77 to 95 per cent of total coliform and 60 to 79 per cent of fecal coliform in the Mobile River entering Mobile Bay) were removed and all other conditions remained constant; viz. same input from tributaries, same dieaway and dilution characteristics, it is probable that,

because of the direct correlation between coliform and fresh water flow, coliform densities would exceed the 70/100 ml standard for shellfish harvesting during high flow periods in all sections of Mobile Bay except Bon Secour Bay. Under these circumstances, total coliform densities in the shellfishing areas would probably be between 200 and 400/100 ml. Fecal coliform, however, would most likely not exceed 25/100 ml. It should be emphasized that this represents only a judgmental extrapolation based on certain assumptions and could only be directly demonstrated after reduction or elimination of Mobile's pollution load (see projected concentrations at oyster beds). If a fecal coliform criterion is applied in determining acceptability for shellfish harvesting, removal of the fecal coliform contributed from above to below the Mobile metropolitan area will be necessary.

Methods for the detection of pathogenic organisms have, until recently, been too complicated for use in field determinations. There are now refined qualitative methods which makes possible the isolation of the genus Salmonella, one of the most common enteric pathogens, in a relatively convenient manner which is adaptable to field survey procedures. It is, therefore, recommended that any control program to more effectively evaluate acceptability of waters in Mobile Bay for shellfishing use, should equally emphasize: 1) a sanitary survey to delineate possible sources of pollution, 2) effective disinfection of all waste sources which may affect the area, and 3) use of fecal coliform as a primary monitoring device in conjunction with Salmonella determinations to more effectively evaluate the probability of pathogen presence.

VII. Bacteriological Source Survey

To define the bacteriological contribution of wastes from sources in the Mobile area, the Federal Water Pollution Control Administration and the Alabama Water Improvement Commission conducted a field survey during January-February 1969. The objectives of this survey were: to identify sources of total and fecal coliform in the Mobile metropolitan area, including storm water runoff, and to evaluate the relative contribution of each source and; to determine whether currents in Mobile Bay could transport pollutants from the Mobile area to oyster beds in the lower Bay. This survey involved sampling for both quality and flow of twelve municipal and industrial effluents as well as the sewer outfalls of the section of Mobile discharging untreated wastes. Storm water analyses were also made. Coliform sampling of the Mobile River as well as the major tributaries of the river and Mobile Bay was included. A limited study of the current pattern in Mobile Bay was performed.

A) Sampling Procedure

The domestic waste sources sampled included: Threemile Creek, Halls Mill Creek, Bill Ziebach, McDuffie Island and Eslava Creek sewage treatment plants of the city of Mobile. Other domestic waste sources sampled were the two Prichard sewage treatment plants and the Chickasaw waste lagoon. Sampling was also conducted at the following industrial waste sources: International Paper Company, Scott Paper Company, National Gypsum Corporation and Stone Container Corporation. Significant point sources of pollution were not found on Blakely Island and

there was negligible discharge from the Alabama State Docks due to the Atlantic and Gulf coast port strike. Samples were collected from sanitary sewers at the intersections of Commerce and Conti Streets and Water and St. Michael Streets to characterize the contribution from the untreated section of Mobile. The total untreated sewage flow was estimated from figures and calculations contained in a design memorandum from David Volkert Associates to the city of Mobile. Storm water contribution was characterized by samples collected at the Southern Drain, Onemile Creek and the Big Stikney Drain. These points drain about 1700 acres, or approximately one-third of the developed portion of Mobile. The Southern Drain discharges near the mouth of the Mobile River and Onemile Creek and Big Stikney discharge to Threemile Creek.

In the receiving waters, samples were collected at five locations in the Mobile River; the Louisville and Nashville railroad bridge above sources of waste, below Chickasaw Creek, below Threemile Creek, above the untreated section of Mobile and at the mouth of the river between McDuffie Island and Pinto Island. Analyses were made at quarter points and at the surface and 20 foot depths in the Mobile River. Points above and below sources of waste on Chickasaw Creek, Eightmile Creek, Threemile Creek, Eslava Creek, Halls Mill Creek and the Dog River were established. Coliform concentrations at the oyster beds were also determined.

An FWPCA mobile laboratory was located at the McDuffie Island sewage treatment plant. All samples were processed within six hours of collection. For the point sources of waste, samples were collected every hour and composited every four hours for a 24-hour period. Daily

samples were taken for six days in the Mobile River and six samples were taken from each tributary station. Collections were made from the sanitary sewers at three-hour intervals from 8:00 AM to 6:00 PM and at four-hour intervals from 8:00 PM to 6:00 AM for one 24-hour period. Four storm water samples were collected on two occasions from each location after rainfall and storm runoff had begun. All preservations and analyses were performed according to procedures enumerated in the twelfth edition of Standard Methods for the Analysis of Water and Wastewater. The multiple tube most probable number technique was used exclusively for total and fecal coliform. All sources of waste and sampling locations are shown in Figure 14 and Appendix E.

B) Hydrology and Current Study

During the survey, the average combined flow of the Alabama and Tombigbee Rivers was 137,220 cfs. Measurements of velocity and cross sectional area showed that approximately 36,000 cfs was flowing in the Mobile River itself. All flows are summarized in Table IX and are based on individual measurements.

Although weather was not favorable for the operation of small craft on Mobile Bay, a limited current study was made on February 4-5, 1969. A synoptic profile of the velocity and direction of water at the surface and at the 10-foot depth was obtained as closely as possible to the time of ebb slack current. Total fresh water inflow to the Bay during this period ranged from 84,000 to 110,000 cfs. The tides were lower than predicted due to a strong north wind. These low tides combined with the increasing flows from the river system would produce a stronger than expected movement of fresh waste down

FIGURE 14

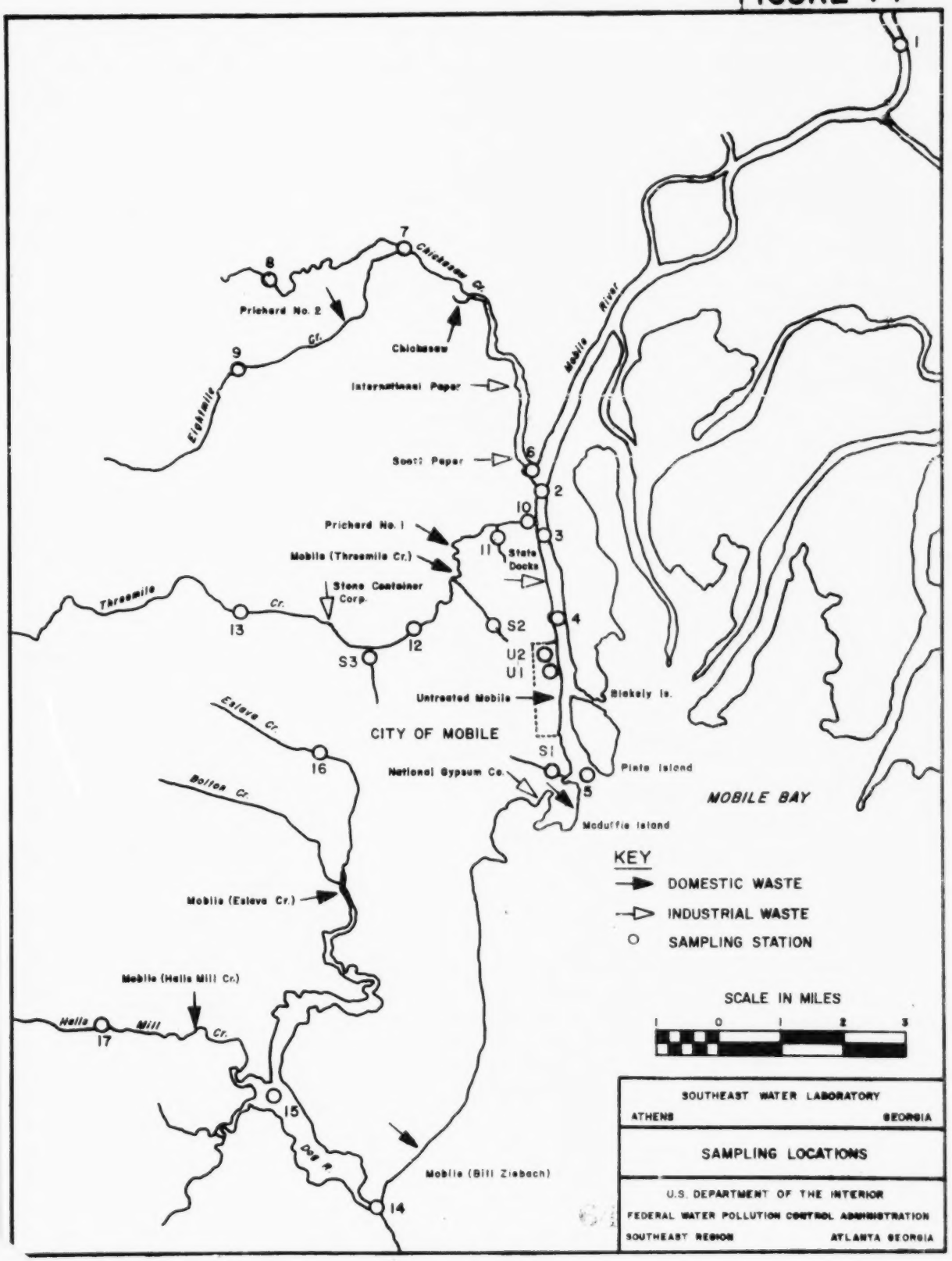

1
Chickasaw Cr.
Mobile River
7
8
Prichard No. 2
Gr.
Chickasaw
9
Eightmile
International Paper
Scott Paper
6
2
10
Prichard No. 1
3
11
State Docks
Mobile (Threemile Cr.)
Stone Container Corp.
Threemile
Cr.
13
12
S2
4
S3
U2
U1
Untreated Mobile
Blakely Is.
Eslava Cr.
CITY OF MOBILE
16
S1
National Gypsum Co.
Pinto Island
5
MOBILE BAY
Bolton Cr.
Mobile (Eslava Cr.)
Mobile (Halls Mill Cr.)
Halls Mill Cr.
17
15
Dog R.
Mobile (Bill Ziebach)
14
KEY
DOMESTIC WASTE
INDUSTRIAL WASTE
SAMPLING STATION
SCALE IN MILES
1 0 1 2 3
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
SAMPLING LOCATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA GEORGIA

TABLE IX

Average River Flows

Mobile Area

February 1969

Waterway	Average Flow (cfs)
Alabama & Tombigbee Rivers	137,220*
Mobile River at Mobile	36,000
Chickasaw Creek	155 *
Eightmile Creek	46
Threemile Creek	14
Halls Mill Creek	43
Eslava Creek	4

*U. S. G. S. measurement - preliminary and subject to revision.

the Bay. The current profiles are shown in Figures 15 and 16.

These current profiles confirm the distribution demonstrated by the coliform isolines from previous surveys in Mobile Bay. Surface water tends to move down the western side of the Bay from both the Mobile and Tensaw Rivers on both tidal currents. The magnitude of the velocity of net movement is directly dependent upon the quantity of freshwater inflow. Although the observed velocities are not the maximums that occur, the maximum slack velocity was 0.9 miles per hour at the surface in the ship channel. At this velocity, it would be possible for water from the Mobile River to reach the shellfish beds in about one day's time of travel.

Currents on the bottom of the upper Bay are variable and generally weaker except in the ship channel. Tidal currents predominated only at depths greater than the natural depth, such as in the ship channel. A saltwater wedge did exist in the channel as far as the mouth of Chickasaw Creek during flood current. The interface between fresh and saltwater was between 15 and 20 feet deep off McDuffie Island and 25 to 30 feet at Chickasaw Creek.

The currents in the lower Bay below Great Point Clear are variable but tidal dependent. Surface water exhibits a net counter-clockwise movement because of the combination of flood tides entering the Bay from Mississippi Sound and the Gulf of Mexico, and the freshwater inflow from the Mobile River system. These conditions, combined with the natural Coriolis effect in estuaries, accentuate the movement of water down the Bay in the direction of and along the western shore.

FIGURE 15

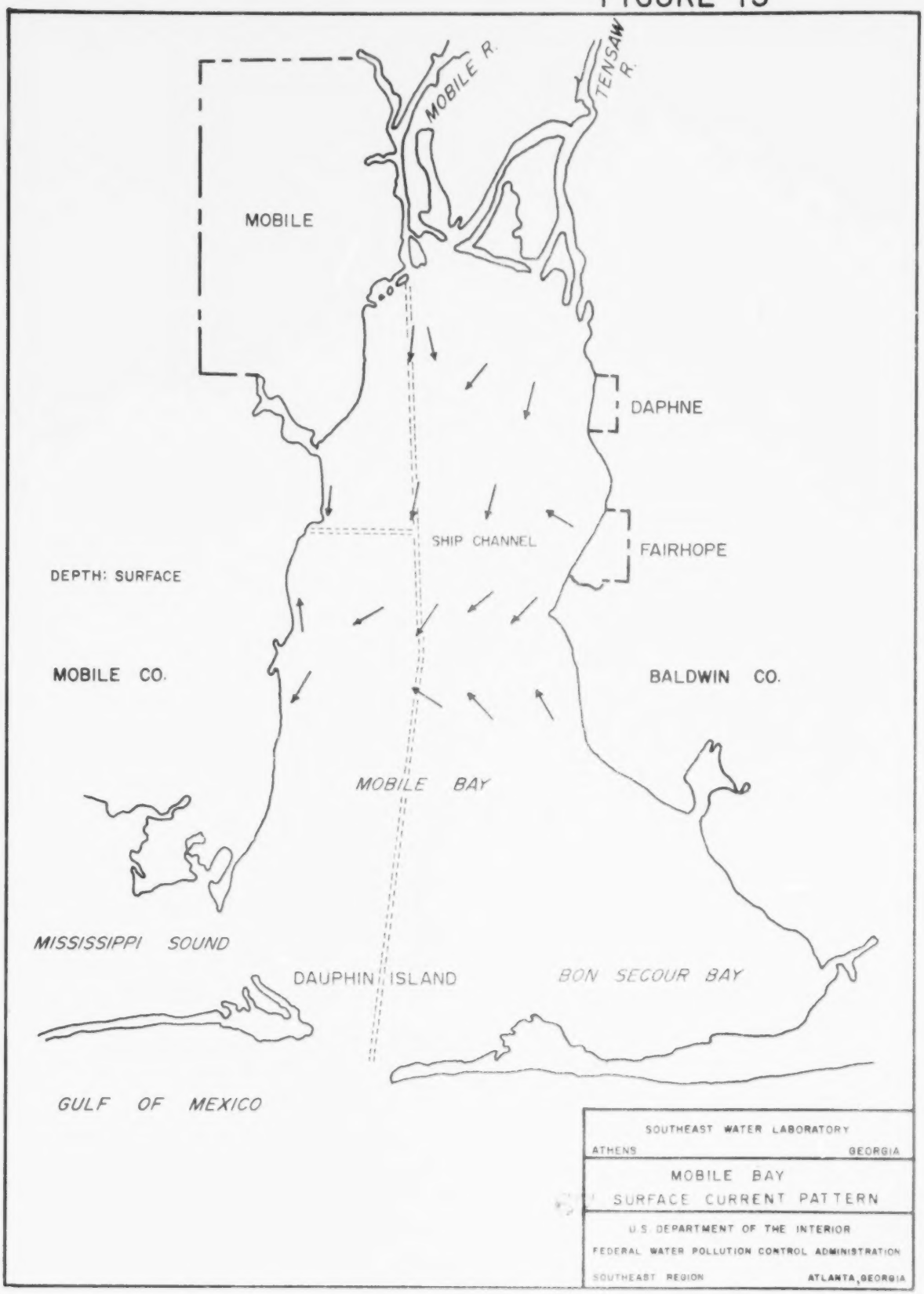
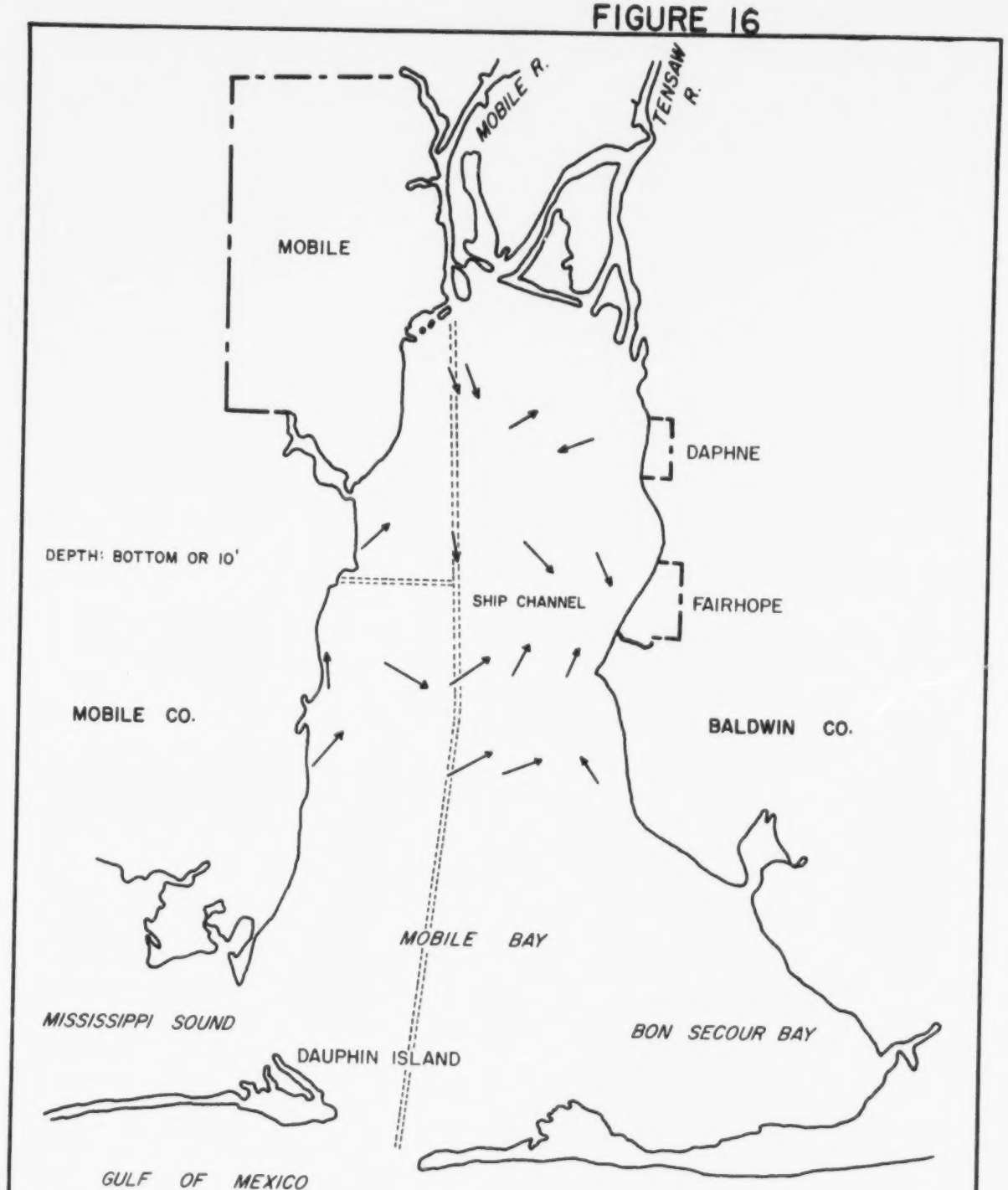

MOBILE R.
TENSAW R.
MOBILE
DAPHNE
SHIP CHANNEL
FAIRHOPE
DEPTH: SURFACE
MOBILE CO.
BALDWIN CO.
MOBILE BAY
MISSISSIPPI SOUND
DAUPHIN ISLAND
BON SECOUR BAY
GULF OF MEXICO
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
MOBILE BAY
SURFACE CURRENT PATTERN
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

FIGURE 16



SOUTHEAST WATER LABORATORY
ATHENS GEORGIA

MOBILE BAY
BOTTOM CURRENT PATTERN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

C) Effluent Evaluation

To permit comparison of the relative significance of each of the waste inputs, coliform concentrations were converted to bacterial population equivalents (BPE) according to the following relationship:(13)

$$BPE = Q\ (cfs)\ X\ MPN/100\ ml\ X\ 1.94\ X\ 10^{-4} \qquad (1)$$

Although this relationship was derived for total coliform only, the fecal coliform observations have also been converted to BPE for purposes of comparison. The median values for each point source of waste are shown in Table X.

There is no significant bacteriological pollution being discharged from the Halls Mill Creek, Bill Ziebach and McDuffie Island sewage treatment plants of the city of Mobile or from the two Prichard installations. Concentrations of total coliform, however, indicate that closer attention to proper operation may be necessary at Mobile's Halls Mill Creek plant (28,450/100 ml) and possibly at Prichard's Threemile Creek plant (2700/100 ml). The other three domestic waste sources - Mobile's Threemile Creek and Eslava Creek plants and Chickasaw's lagoon - are discharging excessive concentrations of both total and fecal coliform. Chickasaw does not have disinfection facilities and the effluent total and fecal coliform were 1,100,000/100 ml and 330,000/100 ml, respectively. The Eslava Creek plant is heavily overloaded and consequently treatment efficiencies are less than desirable. The relative total and fecal concentrations were 2,400,000/100 ml and 1,595,000/100 ml. Respectively the Threemile Creek plant is Mobile's second largest, discharging 6.5 MGD. Bacterial disinfection was not effective at this plant during the survey. Effluent concentrations of

TABLE X

BACTERIAL WASTE SOURCES

Waste Sources	*Flow MGD	Median Coliform Concentrations MPN/100 ml		Bacterial Population Equivalent		% Total Contribution from Mobile	
		Total	Fecal	Total	Fecal	Total	Fecal
Domestic-Mobile							
Halls Mill Creek STP	0.26	28,450	120	2	0	0	0
Threemile Creek STP	6.48	960,500	41,950	1,870	80	1.6	0.3
Bill Ziebach STP	0.27	600	125	0	0	0	0
McDuffie I. STP	6.68	490	35	1	0	0	0
Eslava Creek STP	4.3	2,400,000	1,595,000	3100	2,060	2.6	7.1
Prichard							
Threemile Creek STP	1.88	2,700	435	2	0	0	0
Eightmile Creek STP	0.79	80	20	0	0	0	0
Chickasaw							
Chickasaw Lagoon	1.09	1,100,000	330,000	360	110	0.3	0.4
Industrial							
Stone Container Corp.	0.41	3,500,000	505,000	430	60	0.4	0.2
National Gypsum Co.	1.12	16,000,000	6,350,000	5390	2140	4.6	7.4
Scott Paper Co.	62.8	230,000	54,000	4340	1020	3.7	3.5
International Paper Co.	34.4	5,400,000	945,000	55,900	9,780	47.4	33.8
Untreated Section of Mobile	2.12	73,000,000	21,450,000	46,500	13,700	39.4	47.3

*Average during study period.

total and fecal coliform were 960,500/100 ml and 41,950/100 ml. On a mass basis, these three sources discharge 5,330 BPE of total coliform and 2,250 BPE of fecal coliform. These quantities represent 4.5% of the total coliform discharged from point sources of waste and 7.8% of the fecal coliform.

All of the industrial waste sources were discharging significant concentrations of both total and fecal coliform. The largest contributor on a mass basis is the International Paper Company, with a median total coliform discharge of 55,900 BPE and 9,780 BPE of fecal coliform and 5,400,000/100 ml and 945,000/100 ml, respectively. Bacteriological pollution discharged from this installation represented 47.4% of the total coliform and 33.8% of the fecal coliform from all sources investigated. As listed previously, International Paper Company provides primary treatment only for the industrial waste and a septic tank for the domestic waste. The total waste discharge is about 34 MGD. The average temperature of the effluent was 39°C, which is reasonably close to the optimum growth temperature range for both total and fecal coliform. It is possible that the industrial process is acting as an incubator mechanism and causing multiplication of total and fecal coliform.

The other industrial waste sources in order of quantity of bacteria discharged are the National Gypsum Company, Scott Paper Company and Stone Container Corporation. National Gypsum Company had concentrations of total and fecal coliform from three to six times greater than any of the other sources at 16,000,000/100 ml and 6,350,000/100 ml, respectively. Scott Paper Company had the lowest concentrations

at 230,000/100 ml and 54,000/100 ml, respectively. However, Scott discharges flume water which is relatively low in coliform with process water, thereby diluting concentrations and lowering the temperature to below that for optimum growth rates. In addition, Scott's water intake is located in Chickasaw Creek upstream from the severely polluted reach, whereas International Paper's intake is located in the heavily polluted reach. Thus, Scott discharged only about one-thirteenth of the quantity of coliform as International Paper.

The four industrial sources sampled contribute 56.1% of the total coliform and 44.9% of the fecal coliform. All of the plants had inadequate treatment for both domestic and industrial wastes. For the most part, they provide septic tanks and primary treatment, respectively. Scott was providing primary treatment for a mixture of domestic and industrial wastes. Nearly 66,060 BPE of total coliform and 13,000 BPE of fecal coliform are discharged collectively by these sources.

The second greatest single source of coliform pollution in Mobile metropolitan area is the untreated section of Mobile. Concentrations of total and fecal coliform had medians of 73,000,000/100 ml and 21,450,000/100 ml. An estimated quantity of 46,500 BPE of total coliform and 13,700 BPE of fecal coliform is discharged. These figures represent 39.4% of all of the total coliform and 47.3% of the fecal coliform. Currently an interceptor sewer is being built to transport these wastes to the McDuffie Island plant for treatment.

The thirteen point sources of pollution sampled in the Mobile metropolitan area discharge more than 117,900 BPE of total coliform and 28,950 BPE of fecal coliform. Under present treatment plans, it

is estimated that this total will be reduced by approximately half within the next two years due to the interception of downtown Mobile sewage. At that time, if present operating conditions continue, it is estimated that the industrial sources will contribute 92% of the total coliform and 85% of the fecal coliform discharged. An abatement program is required which provides for secondary treatment and effective disinfection for all sanitary wastes. Operation of all waste abatement facilities should be at the highest possible removal efficiencies at all times. The Eslava Creek sewage treatment plant should be upgraded as soon as possible and the effluent from the Chickasaw lagoon should be chlorinated. Operating improvements should be made at Mobile's Threemile Creek plant. All industries should completely separate their process and domestic wastes and provide immediate secondary treatment and chlorination or connection to the municipal sewerage system for the latter. Secondary treatment should also be provided for all process wastes. If a total or fecal coliform standard for shellfish is employed, these process wastes should receive effective disinfection.

The contribution of coliform pollution from storm water was examined during two rainstorms on February 6 and 8, 1969. The total rainfall on both days was 0.08 inches and 0.28 inches, respectively. Although these totals do not represent an intense rain, the storms, particularly the second one, were characterized by a series of short heavy downpours. Only one sample was collected during the second storm. The results of these analyses are shown in Table XI. Runoff was estimated using the rational formula:

TABLE XI

Storm Water Coliform Pollution

Storm Drain	c	Drainage Area (acres)	Q (cfs)	Median Coliform Conc. MPN/100 ml		B.P.E.*	
				Total	Fecal	Total	Fecal
Storm of 2/6/69							
Southern Drain	0.425	510	5.0	330,000	49,000	320	47
Big Stikney	0.40	547	5.0	330,000	110,000	322	107
Onemile Creek	0.58	640	8.5	3,300,000	3,300,000	5,430	5,430
Storm of 2/8/69							
Southern Drain	0.425	510	6.7	1,100,000	170,000	1,430	223
Big Stikney	0.40	547	6.8	940,000	170,000	1,240	225
Onemile Creek	0.58	640	11.5	35,000,000	13,000,000	78,000	29,000

*Bacterial Population Equivalent

$$Q = c \cdot i \cdot a \qquad (2)$$

where Q = runoff in cfs

c = runoff coefficient

i = rainfall intensity in inches/hour

a = drainage area in acres

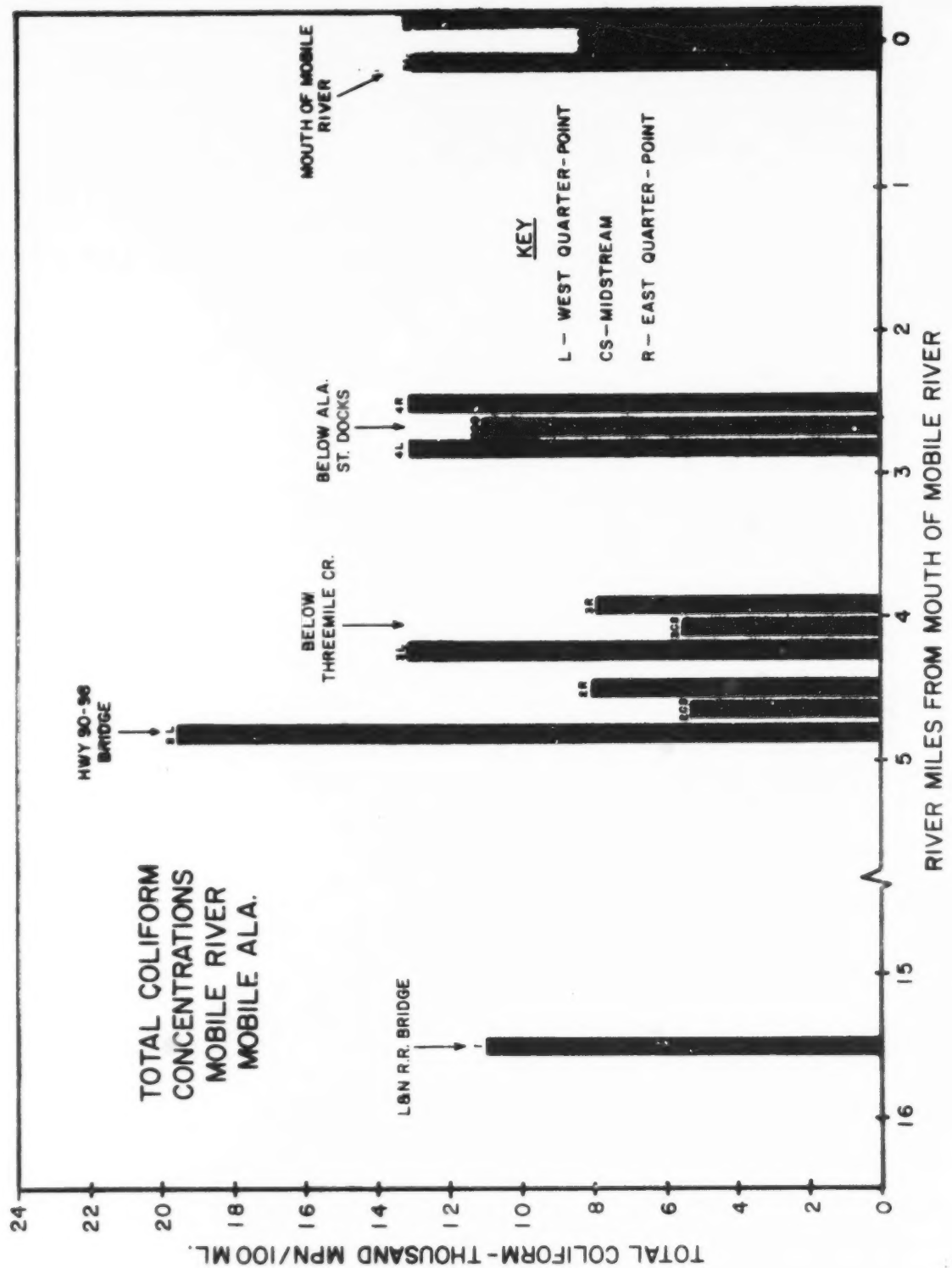
It is hypothesized that there must be a source of waste on Onemile Creek to produce the excessive concentrations shown. Therefore, consideration was limited to an evaluation of the Southern and Big Stikney drains only. The second storm had about 3.5 times more quantity of rainfall and about four times more total coliform and three times more fecal coliform than the first storm. The two drainage areas under consideration constitute about 16% of the developed area in Mobile. If the figures were extrapolated to the city, approximately 3,970 BPE of total coliform and 985 BPE of fecal coliform would have been discharged during the first storm. The second storm would have produced 16,850 BPE and 2,860 BPE or total and fecal coliform, respectively. These figures do not include the built up areas of Prichard and Chickasaw. During these relatively light rainfalls, the storm water coliform contribution from Mobile alone approximated 3-14% of the contribution from point sources of pollution. More intense rainfall would produce a greater percentage. During the periods of time that they occur, storm water overflows are significant sources of coliform pollution in the Mobile metropolitan area.

D) River and Tributary Evaluation

Daily samples from the Mobile River were collected for bacterial analyses on February 4-10, 1969. Samples were not collected on February 6, 1969 due to a rainstorm. The bacterial concentrations in the river on February 5 were disregarded in the evaluation because they were significantly lower than all other values, indicating that conditions in the river on February 5 were not representative of conditions during the remainder of the survey. The average temperature in the Mobile River was 12°C during the study.

The background bacterial concentration in the Mobile River system was determined at the L & N Railroad Bridge (Sta. 1), 15.5 miles above the mouth of the river. The median total coliform concentration was 11,000 MPN/100 ml and the fecal coliform concentration was 4,600 MPN/100 ml. The median total and fecal coliform concentrations in the Mobile River are presented in Table XII and Figures 17, 18 and 19. The surface coliform concentrations at the Highway 90-98 Bridge (Sta. 2) in the center of the channel were considerably reduced from the values at the L & N bridge. Since it was observed that waste entering the river from Chickasaw Creek, which is just upstream from this location, was not thoroughly mixed through the cross section and there are no known waste sources above the station, the reduction in bacterial concentration was presumed due to natural dieoff. The effects of pollution from Chickasaw Creek were evident at the west-quarter point. The median total coliform concentration was 19,500 MPN/100 ml, which was the highest concentration observed in the Mobile River during

FIGURE 17


TOTAL COLIFORM CONCENTRATIONS MOBILE RIVER MOBILE ALA.
HWY 90-98 BRIDGE
BELOW THREEMILE CR.
BELOW ALA. ST. DOCKS
MOUTH OF MOBILE RIVER
L&N R.R. BRIDGE
KEY
L - WEST QUARTER-POINT
CS-MIDSTREAM
R - EAST QUARTER-POINT
TOTAL COLIFORM-THOUSAND MPN/100 ML.
RIVER MILES FROM MOUTH OF MOBILE RIVER

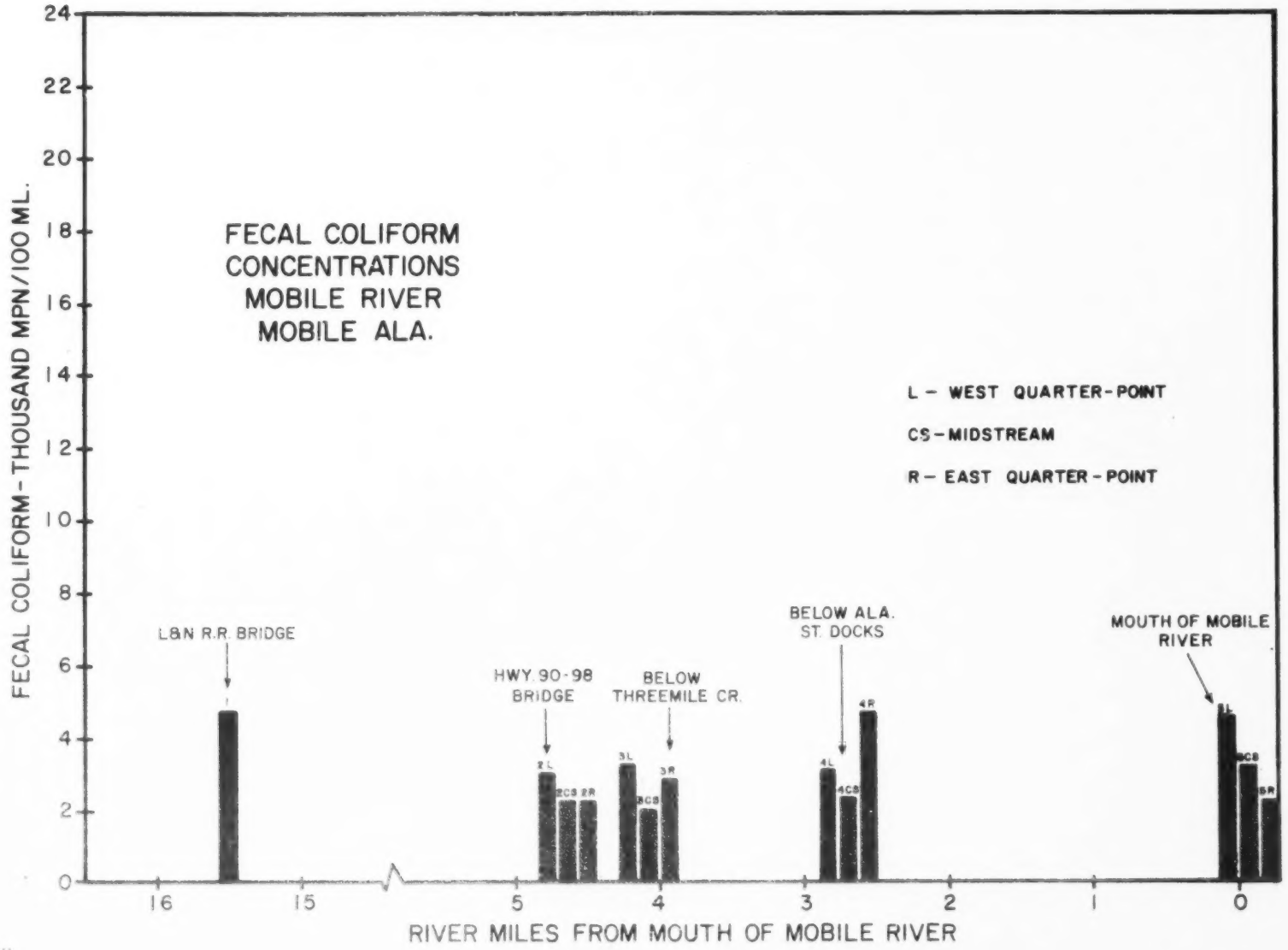

FECAL COLIFORM CONCENTRATIONS MOBILE RIVER MOBILE ALA.
L – WEST QUARTER-POINT
CS – MIDSTREAM
R – EAST QUARTER-POINT
FECAL COLIFORM - THOUSAND MPN/100 ML.
24
22
20
18
16
14
12
10
8
6
4
2
0
L&N R.R. BRIDGE
HWY. 90-98 BRIDGE
BELOW THREEMILE CR.
BELOW ALA. ST. DOCKS
MOUTH OF MOBILE RIVER
2L
2CS
2R
3L
3CS
3R
4L
4CS
4R
5L
5CS
5R
16
15
5
4
3
2
1
0
RIVER MILES FROM MOUTH OF MOBILE RIVER

FIGURE 18

FIGURE 19

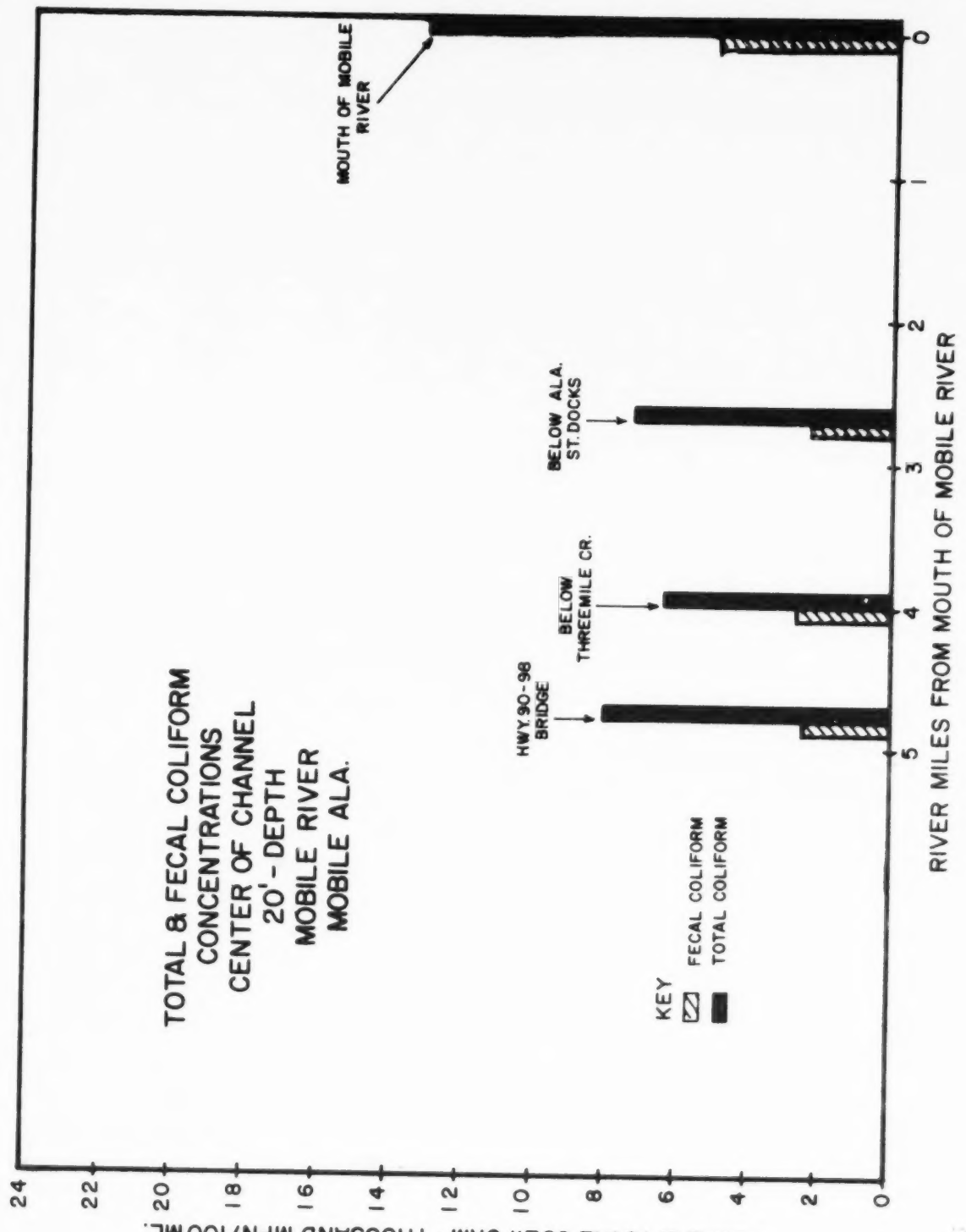

TOTAL & FECAL COLIFORM
CONCENTRATIONS
CENTER OF CHANNEL
20'-DEPTH
MOBILE RIVER
MOBILE ALA.
KEY
FECAL COLIFORM
TOTAL COLIFORM
MOUTH OF MOBILE RIVER
BELOW ALA. ST. DOCKS
BELOW THREEMILE CR.
HWY. 90-98 BRIDGE
FECAL & TOTAL COLIFORM - THOUSAND MPN/100 ML.
0
2
4
6
8
10
12
14
16
18
20
22
24
RIVER MILES FROM MOUTH OF MOBILE RIVER
0
1
2
3
4
5

TABLE XII

Coliform Concentrations in the
Mobile River and its Tributaries

Station	Location	Total Coliform Median MPN/100 ml	Fecal Coliform Median MPN/100 ml
MOBILE RIVER			
1	L&N R.R. Bridge	11,000	4,600
2R	HWY 90-98 Bridge	7,900	2,300
2C-S		4,900	2,300
2C-20		7,900	2,200
2L		19,500	3,300
3R	Below Threemile Creek	7,900	2,800
3C-S		5,600	1,950
3C-20		6,400	2,800
3L		13,000	3,300
4R	Below Alabama State Docks	13,000	4,900
4C-S		11,000	2,200
4C-20		7,000	2,200
4L		13,000	3,300
5R	Mouth of Mobile River	13,000	2,300
5C-S		7,900	3,300
5C-20		13,000	4,900
5L		13,000	4,600
CHICKASAW CREEK			
6	Mouth	130,000	49,000
8	Above Waste Sources	1,100	330
9	Eightmile Cr. above waste source	6,400	860
THREEMILE CREEK			
10	Mouth	48,000	4,900
11	Mouth of Ind. Canal	675,000	62,500
13	Above waste sources	1,100	270
DOG RIVER			
14	Mouth	12,000	1,750
15	Below Confl. of Eslava & Halls Mill Creek	2,200	170
16	Eslava Cr. at Hwy. 90	380,000	122,400
17	Halls Mill Creek at Hwy 90	3,550	440

the study. The median total coliform concentrations at the west-quarter point below Threemile Creek (Sta 3L), below the Alabama State Docks (Sta 4L) and at the mouth of the Mobile River (5L) were all 13,000 MPN/100 ml. Median fecal coliform concentrations were 3,300 MPN/100 ml at all west-quarter point stations, except at the mouth of the river (5L). The median concentration at the mouth was 4,600 MPN/100 ml. Median concentrations of total coliform at the east-quarter point stations were 7,900 MPN/100 ml at stations above the Alabama State Docks and 13,000 MPN/100 ml at stations below the docks. The median fecal coliform concentrations at the east-quarter point ranged from 2,300 MPN/100 ml at the Highway 90-98 bridge (Sta 2R) to 4,900 MPN/100 ml below the Alabama State Docks (Sta 4R). The median concentrations of total and fecal coliform in the center of the channel were considerably lower than concentrations at either of the quarter-points. This indicates that wastes entering the river from Mobile are not completely mixed throughout the river above its mouth. Median total and fecal coliform concentrations in the center of the channel at a depth of 20 feet were equal to or slightly higher than concentrations at the surface.

Significant waste sources discharging to Chickasaw Creek are the Scott Paper Company, International Paper Company and the Chickasaw lagoon. Median total and fecal coliform concentrations, above all known waste sources, in Chickasaw Creek (Sta 8) was 1,100 and 330 MPN/100 ml, respectively. Eightmile Creek (Sta 9), the major tributary of Chickasaw Creek, had 6,400 MPN/100 ml of total coliform, and 860 MPN/100 ml of fecal coliform in it above waste sources. Below the waste sources (Sta 6), the total coliform count was 130, 000 MPN/100 ml and the fecal count was 49,000 MPN/100 ml.

Above all waste sources in Threemile Creek the total and fecal coliform counts were 1,100 and 270 MPN/100 ml, respectively. The concentrations in the mouth of the Industrial Canal (Sta 11) were: total coliform 675,000 MPN/100 ml and fecal coliform 62,500 MPN/100 ml. The Alabama State Docks, which are adjacent to the Industrial Canal, appear to be the source of these high coliform concentrations. The Stone Container Corporation and Mobile's Threemile Creek sewage treatment plant are souces of bacterial pollution in Threemile Creek. The total coliform concentration at the mouth of Threemile Creek (Sta 10) was 48,000 MPN/100 ml and the fecal coliform concentration was 4,900 MPN/100 ml.

The only known significant waste source in the Dog River basin is Mobile's Eslava Creek sewage treatment plant. Concentrations of total and fecal coliform were 380,000 MPN/100 ml and 62,500 MPN/100 ml, respectively, in Eslava Creek above the sewage treatment plant, indicating that an unknown source of waste discharges to Eslava Creek. The other major tributary of the Dog River is Halls Mill Creek. Concentrations above waste sources in this creek were total coliform 3,550 MPN/100 ml and fecal coliform 440 MPN/100 ml. At the mouth of the Dog River the total coliform was 12,000 MPN/100 ml and the fecal coliform was 1,750 MPN/100 ml.

E) Projected Concentrations at the Oyster Beds

The bacterial water quality of the Mobile River was used as a base to project the total and fecal coliform concentrations that would be expected at the oyster beds if the waste sources from Mobile were significantly reduced. To accomplish this, the coliform concentrations contributed to Mobile Bay from the Mobile River when waste sources are eliminated must be determined. As stated previously, the coliform

concentrations in the center of the channel at the Highway 90-98 bridge (Sta 2) are uncontaminated by wastes from Mobile and represent the remainder of the background coliform concentrations after they have traveled from the L & N Bridge to this station. Figures 20 and 21 illustrate the total and fecal coliform concentration profiles in the center of the channel at the surface. Dieoff in the River was assumed to follow a logarithmic decrease between the L & N and Highway 90-98 Bridges.

$$N = N_0 \cdot 10^{-Kt} \qquad (3)$$

N = number of coliform remaining

N_0 = initial concentration

K = dieoff rate

t = time of travel

The dieoff rates for total and fecal coliform calculated were 0.76 and 0.78/day, respectively. This was based on a calculated average velocity in the river of one mile per hour. Since physical conditions in the river between the Highway 90-98 bridge and the mouth of the river are similar to those upstream, the dieoff rates in the lower reach of the river would be expected to be the same as those previously reported. Therefore, the concentration that would occur at the mouth of the Mobile River with wastes from Mobile chlorinated could be determined by extending the dieoff curves in Figures 20 and 21 to the mouth of the Mobile River (Sta 5C-S). The total and fecal concentrations determined in this manner were 1,600 and 1,450 MPN/100 ml, respectively.

To determine the concentrations at the oyster beds the time of travel between the beds and upper Mobile Bay must be estimated. The flushing time of the bay (15) was used as a base for this evaluation

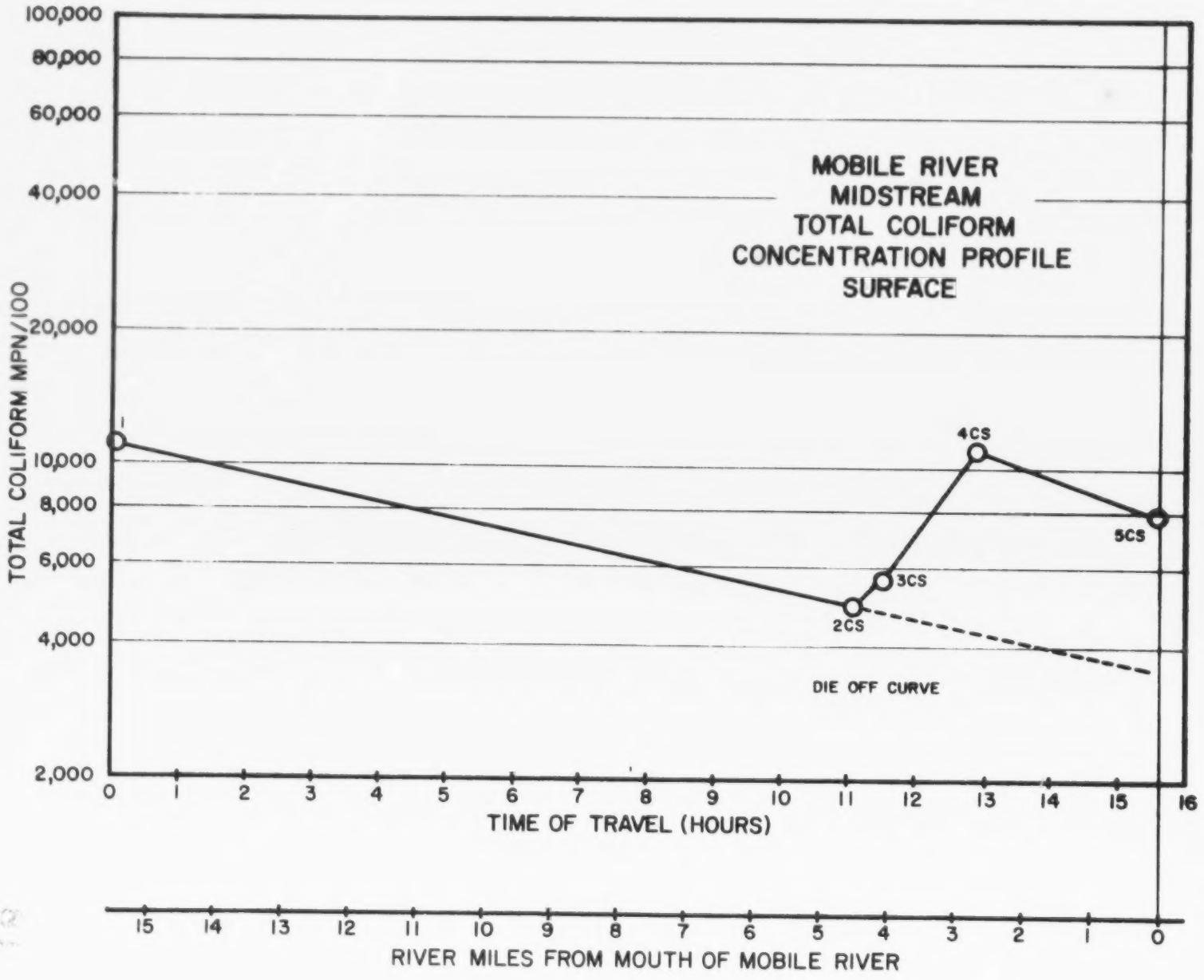
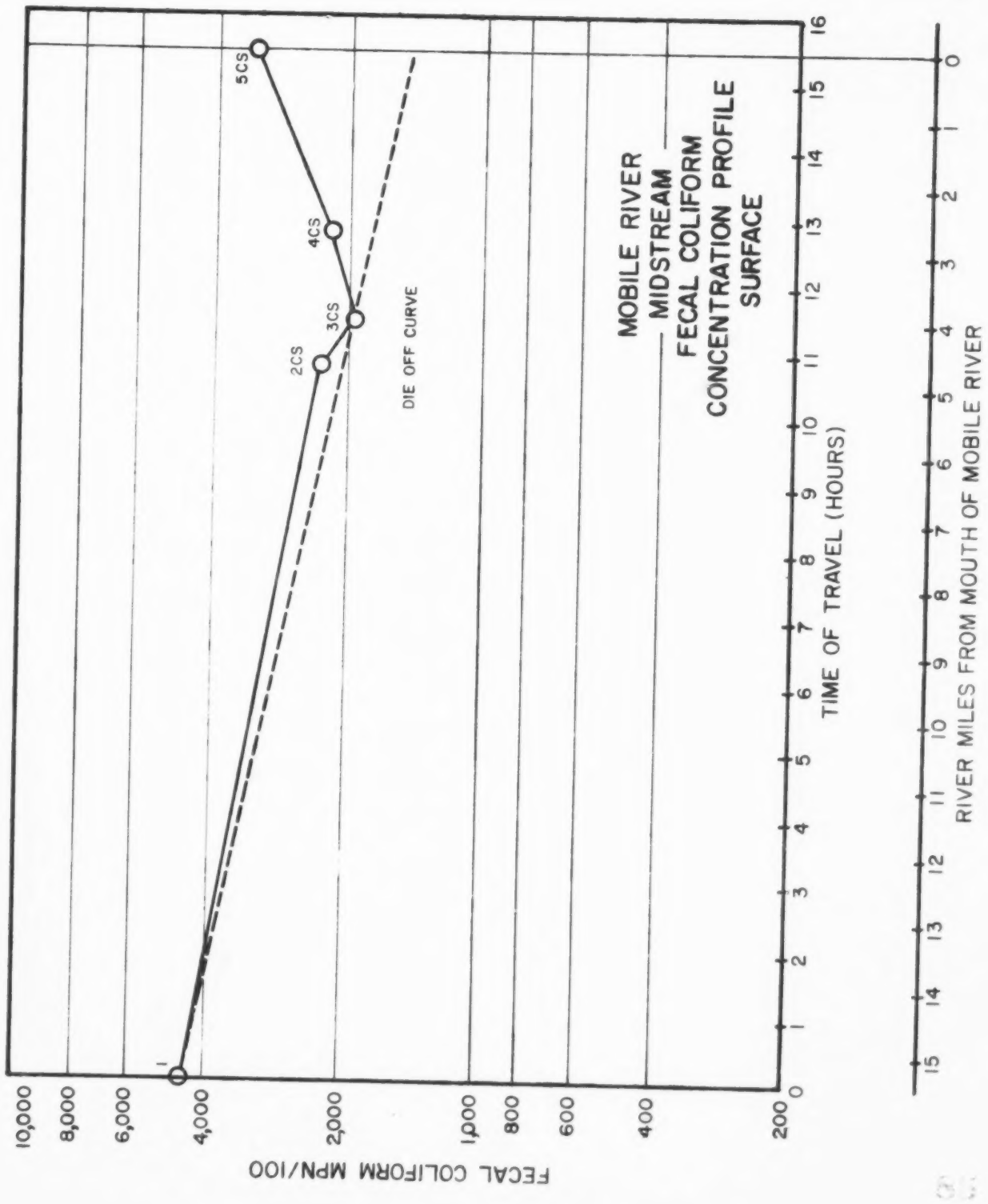

MOBILE RIVER
MIDSTREAM
TOTAL COLIFORM
CONCENTRATION PROFILE
SURFACE
TOTAL COLIFORM MPN/100
100,000
80,000
60,000
40,000
20,000
10,000
8,000
6,000
4,000
2,000
1
2CS
3CS
4CS
5CS
DIE OFF CURVE
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
TIME OF TRAVEL (HOURS)
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
RIVER MILES FROM MOUTH OF MOBILE RIVER

FIGURE 20

FIGURE 21


MOBILE RIVER
MIDSTREAM
FECAL COLIFORM
CONCENTRATION PROFILE
SURFACE
DIE OFF CURVE
1
2CS
3CS
4CS
5CS
FECAL COLIFORM MPN/100
10,000
8,000
6,000
4,000
2,000
1,000
800
600
400
200
TIME OF TRAVEL (HOURS)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
RIVER MILES FROM MOUTH OF MOBILE RIVER
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

and was calculated to be 4.3 days. This assumes that the bay is completely mixed and freshwater flows uniformly down it. This is not the case in Mobile Bay. Current studies and the iso-coliform patterns in the bay indicate that freshwater discharges down the western quarter of the bay. This reduces the effective volume of the bay by 75%. The flushing time of the western quarter of the bay or the time of travel from the freshwater source to the mouth of the bay is, therefore, on the order of one day.

The dieoff rates in Mobile Bay were calculated by assuming the same principle of logarithmic dieoff between Upper Mobile Bay and the oyster beds. The concentrations in upper Mobile Bay were determined by a mass balance of concentrations in the Mobile and Tensaw River. Concentrations at the mouth of the Tensaw River were assumed to be equal to concentrations estimated at the mouth of the Mobile River when wastes from Mobile were eliminated. The calculated median total and fecal concentrations in upper Mobile Bay were 5,760 MPN/100 ml and 1,750 MPN/100 ml, respectively. To determine coliform concentrations at the oyster beds nine samples were collected at the oyster bed in the vicinity of the Dauphin Island Causeway on February 12, 1969. This is one of the most productive oyster beds in Mobile Bay. The median total coliform concentration was 920 MPN/100 ml and the median fecal coliform concentration was 23/100 ml. Using these concentrations and those observed at the mouth of the river with a one day time of travel, the dieoff rates were calcualted to be 0.8 per day for total coliform and 1.9 per day for fecal coliform.

The dieoff rates calculated above were applied to the total coliform concentration of 3,600 MPN/100 ml and fecal coliform concentration of 1,450 MPN/100 ml to estimate median concentrations at the oyster beds with complete abatement of bacterial pollution from Mobile. The concentrations determined were 575 MPN/100 ml of total coliform and 18 MPN/100 ml of fecal coliform. The total coliform concentration would have been approximately eight times higher than the shellfish standard even if no waste was contributed by Mobile.

The results of this investigation indicate that total coliform concentrations at the oyster beds will be significantly greater than the shellfish standard even if complete abatement of wastes from Mobile is achieved. Since these high concentrations can not be associated with fecal pollution, the present shellfish standard appears to be unrealistic. The implementation of a fecal coliform standard would appear to be more reasonable in this case. A coordinated effort by the U. S. Public Health Service and FWPCA should be undertaken immediately to determine an acceptable numerical criterion for fecal coliform with respect to approval of areas for shellfish harvesting.

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APPENDIX

A) Letter of Request from Mayor of Bayou La Batre to Secretary of the Interior

B) National Shellfish Sanitation Program

C) Typical Shellfish Closure Order - Mobile Bay

D) Typical Shellfish Opening Order - Mobile Bay

E) Sampling Stations - January - February 1969

APPENDIX A

City of Bayou La Batre

J. A. (GUSSIE) WINTZELL, MAYOR
BAYOU LA BATRE, ALABAMA 36509

MISS OLGA M. RASMUSSEN
Clerk-Treasurer

March 4, 1968

COUNCILMEN
O. J. BOSARGE
C. LEON McGALLAGHER
HARVEY A. NELSON
M. G. TEMME
J. M. WIGFIELD, JR.

Hon. Stewart L. Udall,
Secretary of the Interior,
Washington, D.C.

Dear Mr. Secretary:

It is my understanding, as the representative leader and having the consent of the City Council, that we have a direct appeal for abatement hearings under the 1965 Water Pollution Act when economic hardships exist when shellfish harvesting and growing areas are closed by state action. As Mayor of the City of Bayou La Batre, Alabama, I am formally requesting the Federal Water Pollution Control Administration for abatement proceedings into the annual closing by the Alabama State Health Department of the oyster reefs of Mobile Bay and adjoining estuarine areas because of bacteriological pollution.

The oyster industry furnishes a minimum of sixty (60) percent of the total economy to our City and a much larger percentage to persons living in the local communities around Bayou La Batre. There are approximately fourteen hundred (1400) oyster licenses issued by the State Conservation Department for taking oysters by tonging in the state. Of the fourteen hundred (1400) issued this year one thousand (1,000) of these licenses are issued to men residing in our local area. The oyster season was closed on January 12th of this year and is still closed as of this date. The pollution problem has caused closure of reefs during peak output for the past eighteen years and the periods of closure have increased as the years have gone by. The closure this year has been the longest and, therefore, indicates that the agents of pollution are increasing in the rivers that empty into Mobile Bay and adjoining estuarine bodies.

The economic hardships derived from the prolonged closure of the oyster reefs have been colossal. Families have had their water, heat, and electricity shut off for nonpayment of bills, foreclosure notices on their homes, mortgage foreclosures on some of the businesses, all of which is no fault of the Oystermen.

Mr. Secretary, we have exhausted all known avenues on the local and state levels for a solution to this pollution problem but have only met a stone wall. We, also, requested help from the U.S. Public Health Service Shellfish Laboratory on Dauphin Island, Alabama, but they informed us they had no authority in the pollution of shellfish in the local area.

Mr. Secretary, I have outlined this problem of pollution and how it has affected us economically. If any additional information is needed please do not hesitate to contact me.

The citizens of Bayou La Batre and the surrounding communities will appreciate every consideration that you and your representatives can give this problem.

Sincerely,

J. A. Wintzell, Mayor

JAW/R

APPENDIX B

NATIONAL SHELLFISH SANITATION PROGRAM

The objective of the National Shellfish Sanitation Program (NSSP) is that shellfish will be safe to eat. Shellfish are filter feeders obtaining their food from the surrounding aquatic environment. Thus, the sanitary quality of shellfish is a function of the sanitary quality of the waters in which they are grown. Under a given set of conditions, shellfish taken from polluted waters can be, and have been, vectors of communicable disease. Since many shellfish are consumed raw or partially cooked, the NSSP places major emphasis on the sanitary quality of the water in which they are grown. As a result, sanitary standards for shellfish growing areas have been established by the NSSP. Growing area standards in Alabama are essentially the same as those of the NSSP. State regulations (and NSSP standards) require state officials to prohibit shellfish harvesting from areas where the coliform levels exceed a median MPN of 70/100ml, or where more than 10% of the samples exceed an MPN of 230. In addition to bacteriological standards, area evaluations are also based on sanitary surveys.

The U. S. Public Health Service (USPHS), in carrying out its responsibilities in the NSSP, periodically evaluates state programs to determine if NSSP requirements are being met. State shellfish sanitation control programs meeting minimum NSSP requirements are endorsed by the USPHS. The USPHS publishes semi-monthly the Interstate Shellfish Shippers List (ISSL), which lists state certified shellfish dealers meeting state and NSSP requirements. The list is distributed

to the shellfish industry, food control authorities, and other interested groups. Through this mechanism, certified shellfish move freely in interstate trade. The shellfish economy of coastal states is heavily dependent upon the market of interior states. Thus, the loss of out-of-state markets would have serious economic impact upon a state's shellfish economy. Loss of market could occur in at least two ways. First, the USPHS could terminate its endorsement of a state's program--with the state's name and shippers deleted from the ISSL--if serious state program defects were observed, and, secondly, state control agencies could remove a dealer's name from the ISSL for violation of public health regulations and thus exclude him from interstate and intrastate trade. In either event, food control authorities in receiving states would not accept shellfish from non-certified sources or from a state whose program was not endorsed by the USPHS.

STATE OF ALABAMA)

MONTGOMERY COUNTY)

APPENDIX C **Typical Closure Order**

I, Ira L. Myers as State Health Officer, acting under the authority vested in me by the laws of the State of Alabama, and pursuant to the rules and regulations of the Alabama State Board of Health governing the production, shucking and handling of oysters, adopted the 19th day of October, 1966, do hereby declare that the following described area is a grossly polluted closed area from which the taking of oysters for market purposes shall not be permitted:

I

CLOSED AREA

1. All that portion of Mobile Bay and tributaries, lying North of a line extending in an Easterly direction from the South bank of East Fowl River at its mouth to lighted beacon flashing every 2 seconds (FL ev 2 sec "2") thence in an Easterly direction to lighted beacon flashing green every 4 seconds (FLG ev 4 sec "23") at Mobile Ship Channel, thence in a Northeasterly direction to Daphne.

2. All of Bayou Coden and that portion of Portersville Bay extending 1000 feet on each side on a straight line connecting the shore to a lighted beacon flashing red (FLR "2") and lighted beacon flashing (FL "1").

3. All of Bayou LaBatre and that portion of the adjoining waters extending 1000 feet on each side of a line connecting lighted beacon fixed red (FR) and lighted beacon fixed red (FR "2").

4. All of that portion of water extending 1000 feet from the outfall of the Dauphin Island sewage treatment plant.

5. All of Bon Secour River lying upstream from a line extending due North from the East bank of the inlet to Oyster Bay from said Bon Secour River.

II

TEMPORARILY CLOSED AREA

1. All that portion of Mobile Bay and tributaries lying South of a line extending in an Easterly direction from the South bank of East Fowl River at its mouth to lighted beacon flashing every 2 seconds (FL ev 2 sec "2") thence in an Easterly direction to lighted beacon flashing green every 4 seconds (FLG ev 4 sec "23") at Mobile Ship Channel, thence in a Northeasterly direction to Daphne.

2. All of Mobile Bay, Heron Bay and that portion of Mississippi Sound and contiguous waters in the Dauphin Island-Cedar Point area East of a line extending in a Southerly direction from a point on Mon Luis Island Midway between Barry Point and Barren Point, to a lighted beacon fixed green (FG) at the intersection of ranges C and D of the Inter-coastal Waterway, and thence due South to Dauphin Island.

The above described area shall be closed for the taking of oysters for market purposes on and after 6 O'clock P.M. the 12th day of January, 1968, and until such future date as the Alabama Department of Public Health, through regulation, may open same.

Maps showing area are on file with the Alabama Department of Public Health, Montgomery, Alabama, the Department of Conservation, Montgomery, Alabama, Baldwin County Health Department, Bay Minette, Alabama, and the Mobile County Health Department, Mobile, Alabama.

Ira L. Myers, M. D.
State Health Officer

Dated this the 10th day of January 1968.

APPENDIX D Typical Opening Order

STATE OF ALABAMA)

MONTGOMERY COUNTY)

Reproduced from best available copy.

I, Ira L. Myers, as State Health Officer, acting under the authority vested in me by the laws of the State of Alabama, and pursuant to the rules and regulations of the Alabama State Board of Health governing the production, shucking and handling of oysters adopted the 19th day of October, 1966, do hereby find that a certain area in Mobile Bay in the State of Alabama, more particularly described below, and part of which area was closed as shown by my order dated the 12th day of January, 1968, is an approved oyster growing area as defined by Section 3 of said rules and regulations, and I, therefore, declare said area to be open to the taking of oysters for market purposes until such future date as the Health Department, through regulation, may close same.

OPEN AREA

All that portion of Mobile Bay and tributaries lying South of a line extending in an Easterly direction from the South bank of East Fowl River at its mouth to lighted beacon flashing every 2 seconds (FL ev 2 sec "2") thence in an Easterly direction to lighted beacon flashing green every 4 seconds (FLG ev 4 Sec "23") at Mobile Ship Channel, thence in a Northeasterly direction to Daphne.

All of Mobile Bay, Herron Bay and that portion of Mississippi Sound and contiguous waters in the Dauphin Island-Cedar Point area East of a line extending in a Southerly direction from a point on Mon Luis Island midway between Barry Point and Barren Point, to the lighted beacon fixed green (FG) at the intersection of ranges C and D of the Intercoastal Waterway, and thence due South to Dauphin Island.

That portion of Bon Secour Bay North and West of a line between the end of Engineers Pier at Ft. Morgan and Mullet Point.

The above described area shall be open for the taking of oysters for market purposes on and after 6 O'clock A.M. this the 4th day of March, 1968, and until such future date as the Health Department, through regulations, may close same.

Maps showing area are on file with the State Health Department, Montgomery, Alabama, the Department of Conservation, Montgomery, Alabama, Baldwin County Health Department, Bay Minette, Alabama and the Mobile County Health Department, Mobile, Alabama.

Ira L. Myers, M. D.
State Health Officer

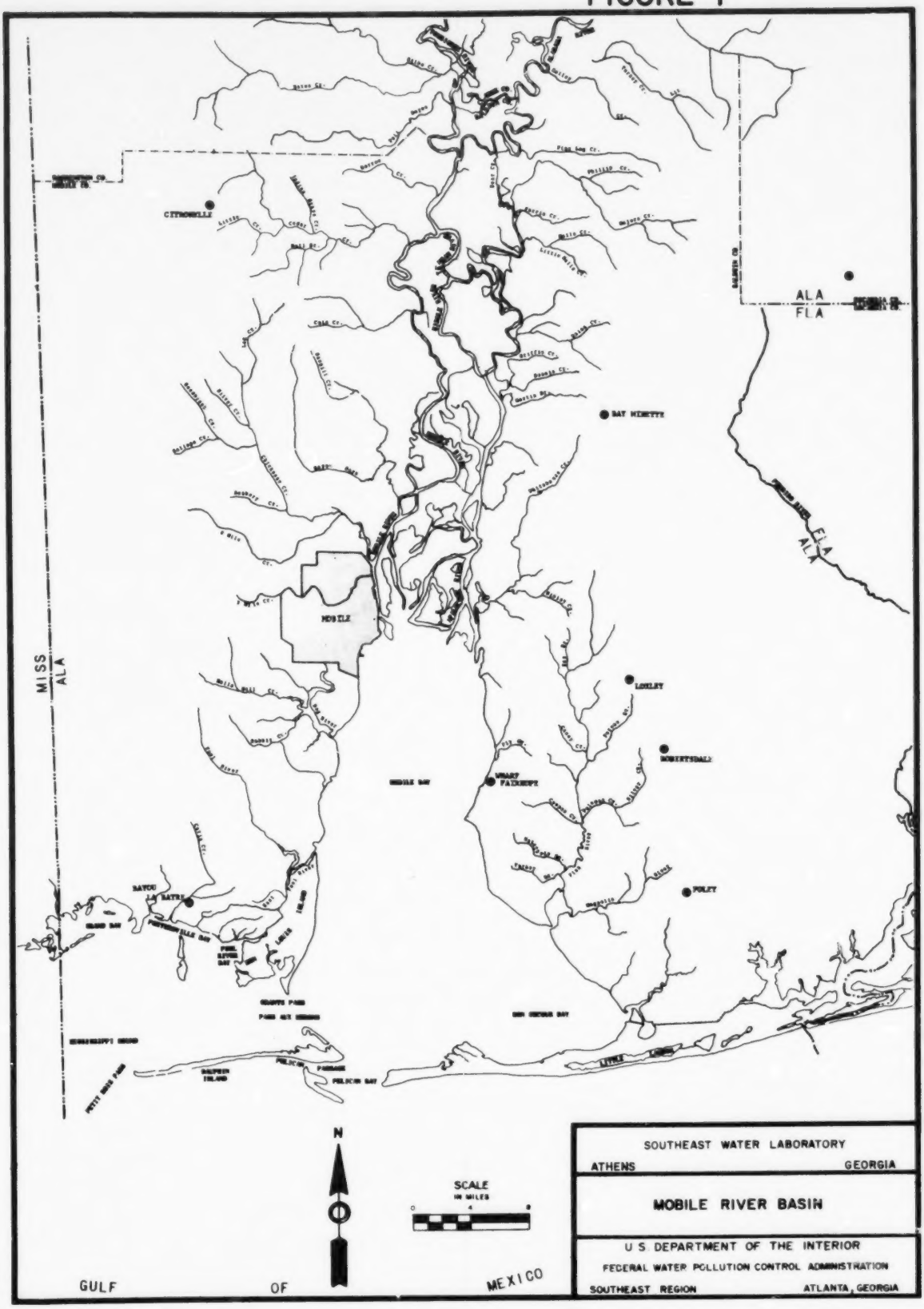
Dated this the 4th day of March, 1968.

APPENDIX E

Sampling Stations
Jan.-Feb. 1969

Station	Location
1	Mobile River - L&N R.R. Bridge - midstream
2L	Mobile River - U. S. Hwy 90 Bridge - west qtr point
2C-S	Mobile River - U. S. Hwy 90 Bridge - midstream
2C-20	Mobile River - U. S. Hwy 90 Bridge - midstream - 20' below surface
2R	Mobile River - U. S. Hwy. 90 bridge - east qtr point
3L	Mobile River - Cable crossing below Threemile Cr. - west qtr. point
3C-S	Mobile River - Cable crossing below Threemile Cr. - midstream
3C-20	Mobile River- Cable crossing below Threemile Cr. - 20' below surface
3R	Mobile River - Cable crossing below Threemile Cr. - east qtr point
4L	Mobile River - opposite Pier A, Ala. State Docks - west qtr point
4C-S	Mobile River - opposite Pier A, Alabama State Docks - midstream
4C-20	Mobile River - opposite Pier A, Ala. State Docks - midstream - 20' below surface
4R	Mobile River - opposite Pier A, Ala. State Docks - east qtr point
4A-L	Mobile River - at Bankhead Tunnel - west qtr point
4A-S	Mobile River at Bankhead Tunnel - midstream
4A-20	Mobile River - at Bankhead Tunnel - midstream - 20' below the surface
4A-R	Mobile River - at Bankhead Tunnel - west qtr point
5L	Mobile River - opposite southern tip of Pinto Island - west qtr point
5C-S	Mobile River - opposite southern tip of Pinto Island - midstream
5C-20	Mobile River - opposite southern tip of Pinto Island - midstream- 20' below surface
5R	Mobile River - opposite southern tip of Pinto Island - east qtr point
6S	Chickasaw Creek - at L&N R.R. bridge - midstream

FIGURE 1


CITRONELLE
MOBILE
BAY MINETTE
LOXLEY
ROBERTSDALE
FOLEY
WEST FAIRHOPE
BAYOU LA BATRE
DAUPHIN ISLAND
MISS
ALA
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FLA
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MOBILE BAY
MOBILE BAY
GULF OF MEXICO
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SCALE
IN MILES
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
MOBILE RIVER BASIN
U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA